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2002 Olympic Winter Games Edition

WINTER 2001 • USDA FOREST SERVICE

NATURAL INQUIRER

Should Ditches Be Graded?
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Beetles Are Supercool!
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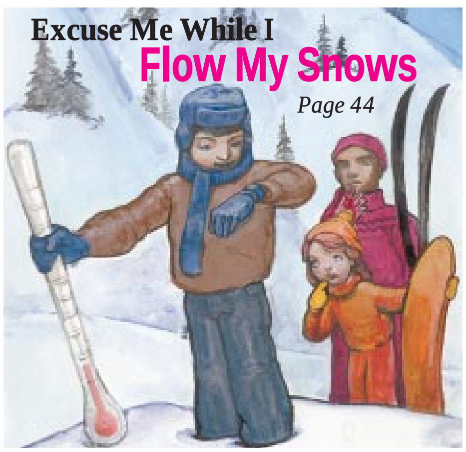

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The Natural Inquirer
Volume 2, No. 2, Winter 2001
The Rocky Mountain Ecoregion

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Teacher's Note

As teachers of science, one of your goals is to teach students the scientific method, no matter what your area of focus—biology, chemistry, physics, etc. The scientific method can best be taught by focusing on inquiry and investigation. This allows the learner to be independent and to seek answers to questions throughout the world we live in. As educators, you are constantly faced with engaging your students in scientific inquiry in new and different ways. Standard teaching strategies can become monotonous to today's learners in an age of abundant technology. *The Natural Inquirer* gives a fresh approach to science and a view of the outside world bigger than the classroom that can be used while still in the school setting.

The Natural Inquirer is a science education resource journal to be used with learners from Grade 5 and up. *The Natural Inquirer* contains articles describing natural resource research conducted by USDA Forest Service scientists. These are scientific journal articles that have been reformatted to meet the needs of an audience new to science. The articles are easy to understand, are shortened, are more aesthetically pleasing to the eye, contain glossaries, and include hands-on activities. The 2002 Olympic Winter Games sidebars show how science is applied to the real world.The goal of *The Natural Inquirer* is critical thinking about scientific inquiry and investigation while learning about our natural resources and the environment.

Past issues and articles from *The Natural Inquirer* are available by visiting the following website: www.naturalinquirer.usda.gov.

Science Education Standards and Evaluations:

In the back of the journal, you will find a matrix that allows you to identify articles by the national science education standards they address. You will also find evaluation forms in the back of the journal. Please make copies of these evaluation forms and have your students complete them after they complete an article. Please note the form for teachers to complete also. Please send the evaluation forms to the address listed at the end of the forms. You and your students may also complete the forms on-line by visiting www.naturalinquirer.usda.gov.

This journal was created by the Urban Tree House, an education program of the USDA Forest Service. If you have any questions or comments, please contact:

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Teacher's Manual:

Please visit *The Natural Inquirer* website at www.naturalinquirer.usda.gov. From this site, you may read the teacher's manual online or download it.

Visit www.naturalinquirer.usda.gov for previous issues of the *Natural Inquirer*, sample lesson plans, word games, the teacher's manual, information about the Forest Service, and other resources.

The Natural Inquirer

Scientists report their research in journals, which are special booklets that enable scientists to share information with one another. This journal, *The Natural Inquirer,* was created so that scientists can share their research with you and with other middle school students. Each article tells you about scientific research conducted by scientists in the USDA Forest Service. If you want to know more about the Forest Service, you can read about it on the back cover of the journal , or you can visit *The Natural Inquirer* website at www.naturalinquirer.usda.gov.

All of the research in this journal is concerned with nature, such as trees, forests, animals, insects, outdoor activities, and water. First, you will “meet the scientist” who conducted the research. Then you will read something special about science, then about the natural environment. You will also read about a specific research project, written in the way that scientists write when they publish their research in journals. You will also become a scientist when you do the FACTivity associated with each article. Don’t forget to look at the glossary and the 2002 Olympic Winter Games sidebar, which will help you understand the article and see how scientific research is used in the real world.

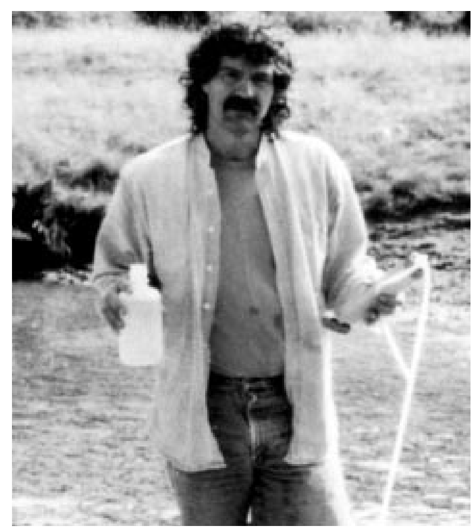
At the end of each section of the article, you will find a few questions to help you think about what you have read. These questions are not a test! They should help you to think more about the research. Your teacher may use these questions in a class discussion.

What Are Scientists?

Scientists are people who collect and evaluate information about a wide range of topics. Some scientists study the natural environment. To be a successful environmental scientist, you must:

- **Be curious** —You must be interested in learning.
- **Be enthusiastic** —You must be interested in an environmental topic.
- **Be careful** —You must be accurate in everything that you do.
- **Be open minded** —You must be willing to listen to new ideas.
- **Question everything** —You must think about what you read and observe.

Scientists in this issue at work.



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OLYMPIC WINTER GAMES

dear naturally inquiring students:

Do you like to discover new things? Are you interested in learning about nature? Then the *Natural Inquirer* is for you! This journal is full of new information on the natural environment that we call the Rocky Mountains. In this *Natural Inquirer,* you will learn how father owls feed their young, the dangers that song-birds sometimes face and how beetles stay warm during the winter. Find out how avalanches are formed, whether trout always pick the same place to swim in a stream and how a computer can be used to predict soil erosion!

The Rocky Mountains are unique and were chosen as the location of the most competitive winter sports event in the world — the Olympic Winter Games of 2002. People everywhere will see that the Rocky Mountains are special. And YOU will know a lot about them, just by reading the *Natural Inquirer*!

We need to protect and care for our natural environment. To do that, we must have a scientific understanding of it — how it works, how we use it, and how it is changing and why. The *Natural Inquirer* will help you to learn about the Rocky Mountains and their use as the setting for the Salt Lake 2002 Olympic Winter Games.

I hope that you enjoy learning about the Rocky Mountains. Being a natural inquirer is fun!

Sincerely,

Diane Conrad

Diane Conrad,
Director, Environmental Programs
Salt Lake 2002 Olympic Winter Games

"we need to protect and care for our natural environment"

Beetles Are Supercool!

Understanding the Life Cycle of Mountain Pine Beetles

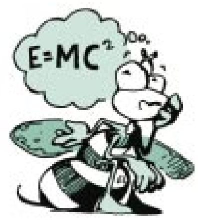
Meet Dr. Jesse Logan:

I like being a scientist because of the excitement of learning new things and the rewards of being creative. I became interested in natural resources as a young boy enjoying the out-of-doors in the Rocky Mountains.

Meet Dr. Barbara Bentz:

I like being a scientist because I enjoy the art of discovery. I became interested in natural resources when I was a young child, traveling and camping with my family.

Thinking About Science



Many plants and animals live in *annual* cycles. They respond to seasonal temperature changes and changes in the length of the day. Some scientists are interested in studying the effect of these seasonal changes on the life cycle of plants and animals. The science that investigates these effects is called *phenology* (fe **näl** uh je). The science of phenology also investigates the influence of *climate* on the life cycle of plants and animals. This is important, because many scientists now believe that our climate is changing. In this study, the scientists were interested in understanding how a change in climate might affect the life cycle of a particular species of beetle. Because they could not wait a hundred or more years

Glossary:

annual (**an** yoo ul): Covering the period of 1 year.

climate (**kli** met): The average condition of the weather at a place.

larva (**lär** vuh): Wormlike feeding form that hatches from the egg of many insects.

metabolize (muh **ta** buh liz): Chemical changes in a living body that provide energy to the cells for survival, growth, and reproduction.

carbohydrate (kär bo **hi** drat): Starches and sugars that are used as food by animals.

phloem (**flo** em): Tissue that transports nutrients from the leaves to the rest of the plant.

pupa (**pyoo** puh): Intermediate stage of insect growth between larva and adult.

resin (**rez** in): Cloudy, sticky substance that oozes from some trees.

population (pop yoo **la** shun): The whole number of individuals of the same type occupying an area.

stand (stand): A group of trees growing in a continuous area.

complexity (kälm **plek** suh te): The state of being complicated or having many related parts.

simulate (**sim** yoo lat): To create the appearance or effect of something for purposes of evaluation.

indicator species (in di **kat** ür **spe** sez): Type of plant or animal that serves as a measure of the environmental health of an area.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

for the climate to change, the scientists used a computer program to predict what might happen.

Thinking About the Environment

Mountain pine beetles *(Dendroctonus ponderosae Hopkins)* are sometimes supercool! This is what scientists call the beetles' ability to "chill out" during the cold winter months, during their *larva* stage (Figure 1). During the winter, the beetle larvae live in the interior of pine trees. Because mountain pine beetles are composed partly of water, they must have made adaptations to keep from freezing in the cold of winter. When water freezes, it forms six-sided crystals. The crystals have sharp edges that could damage the other structures inside of the beetle. Mountain pine larvae have found a way to *metabolize carbohydrates*, which contain water, into glycerol (**glis** ür ol) during the winter months. Glycerol is a form of alcohol, and therefore will not freeze – it is insect antifreeze! When the temperatures turn warm again, the larvae turn the glycerol back into carbohydrates. Carbohydrates are a source of energy for the beetles. Mountain pine beetles have adapted to cold conditions, and this allows them to survive.

Introduction

Mountain pine beetles live for only 1 year. Most of the year is spent "chilling out" in a condition scientists call supercool. Because they live in high mountain environments where it is very cold, they spend most of their short life span being supercool. That does not give them much time to lay eggs and reproduce. When these beetles reproduce, they lay eggs in the *phloem* of pine trees (Figure 2). These eggs become the larvae that live in the phloem during the cold months. In late summer, *pupa* become adults and emerge from the pine trees. As adults, the beetles must bore holes in other pines trees so they can lay their eggs. When they bore holes in the trees and lay eggs, the beetles usually kill the tree. Pine trees produce *resin* to repel the beetles. To successfully lay their eggs, the beetles must work as a team. They bore holes in pine trees in large numbers (Figure 3). When you think about it, you can see that the *population* of mountain pine beetles needs to coordinate its activities. If each individual beetle did these things on its own schedule, the species would not survive.

Mountain pine beetles are part of an ecosystem. When beetles kill a *stand* of weakened trees, natural fire may follow. When fire burns the trees that have been killed by the beetles, the area becomes favorable for new trees to grow. This helps the forest to renew itself. On the other hand, when beetles kill a stand of trees, there are fewer trees that can be used for wood products for human needs.

Remember that mountain pine beetles are dependent on warm weather to reproduce, and they only have part of one summer to lay their eggs before dying. If the climate changes in the future, how will the beetles adjust? The scientists in this study wanted to explore how mountain pine beetles detect when it is time to emerge from pine trees. This information would help the scientists to predict what might happen to the beetles if the climate changes in the future.

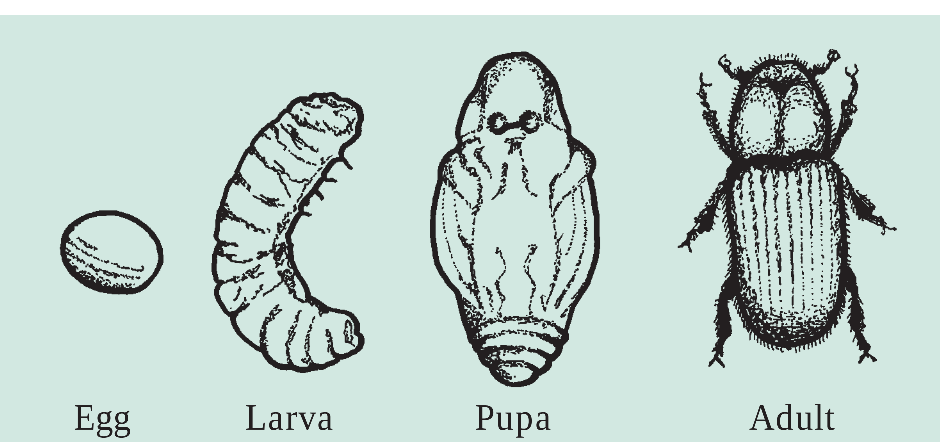


Figure 1. The life stages of the mountain pine beetle, including egg, larva, pupa, and adult.

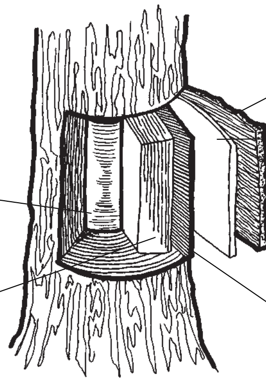


Figure 2. Mountain pine beetles spend much of their life in the phloem of pine trees.

Reflection Section

- Think about the variation in springtime temperatures. How do scientists know that the first very warm day is not the signal used by the beetles to emerge from the trees? What would happen to the beetles if they emerged from the tree on the first warm day?

- When an ecosystem is balanced, it is healthy. A balanced ecosystem means that everything depends on everything else, and no one plant or animal takes over the rest. The pine beetle/pine tree ecosystem is usually balanced between the beetles and the pine trees. This is because the beetles select the weakest trees in which to lay their eggs. Then, the weaker trees die and make room for new, healthier trees. In what ways could the pine beetle/pine tree ecosystem become unbalanced?

Figure 3. A stand of pine trees killed by mountain pine beetles.

Methods

To understand the scientists' methods, you will have to think about the *complexity* of the beetles' life cycle. Thousands of adults must emerge from pine trees at the same time in the late summer. They must emerge after all danger of frost is gone. They cannot wait too long past that date, because they only have a short time to lay eggs before they die in the fall or winter. All of them must bore holes into the pine trees at the same time, or the pine trees will successfully repel them with resin. The scientists needed to know the temperature for the whole life cycle of the beetles (How many days is that? – Hint: Re-read the first sentence of the Introduction.) The scientists used measurements of the temperature that were made every hour of every day for a year. (How many measurements did they use?) They used measurements for 4 different years. (Now multiply the number of measurements by four – how many measurements did they use?)

The scientists already knew a lot about the beetles' life cycle. Using a computer program that contained all of the temperature measurements, they guessed what would happen to a beetle if it emerged from a tree's interior on every day of the year. Using the computer program, they were able to identify which days would be the best ones for the beetles to emerge. Then, they added 2.5 °C to each of the temperature measurements. They did this to *simulate* what might happen when the climate changes in the future, since the general trend is for the Earth to be getting warmer.

Reflection Section

- What are the advantages of using a computer program to simulate the emergence of the beetles? Could the scientists have done the calculations by hand? Why or why not?

- What do you think will happen to the beetle population if the temperature rises by 2.5 °C?

Results

The scientists found that temperature was the most important factor affecting the emergence of beetles from pine trees. The scientists predicted that if global warming occurs (represented by the addition of 2.5 °C to the temperatures), mountain pine beetles could move farther north and into higher mountains. This means that their range could expand. The scientists also predicted that if mountain pine beetles live in warmer climates, they may produce a larger number of eggs. Changes in temperature could also change the timing of their life cycle. The beetles would probably not always emerge from the trees at the same time. Unfortunately for the beetles, this would mean that the teamwork they use to lay their eggs in pine trees would not be as strong.

Reflection Section

- If global change creates warmer temperatures in the future, what do you think might happen to the population of mountain pine beetles? Why?

- If the population of mountain pine beetles begins to increase, what might happen to the population of pine trees? Could any changes be balanced by the lack of beetle teamwork? Why or why not?

Implications

It is clear that global climate change would cause a change in the ecosystem that includes mountain pine beetles and pine trees. The scientists believe that studying mountain pine beetles may help people understand if and how the global climate is changing. If populations of beetles living in high mountain environments are monitored, any change in their patterns of emergence, egg laying, or range might indicate a change in climate. The scientists believe that the mountain pine beetle is a good *indicator species* for environmental change.

Reflection Section

- From what you have observed and learned from school, newspapers, and other places, do you think the global climate is changing? Why or why not?

- What other ways might global climate change be monitored?

- What can humans do to reduce the possibility of global climate change?

FACTivity

Did you know that beetles are one of the most numerous types of life forms on Earth? Beetles live everywhere across the Earth, except in the open ocean. And, beetles are even older than the dinosaurs! To be so successful, beetles have many advantages that help them survive. In this FACTivity, we are going to get to know beetles close up! Get a bug box (a clear plastic box with plenty of room for air). Look outside in your school yard or at home for beetles. Find a beetle, and gently put it in the bug box. After you observe the beetle, you should release it back outside, in the same place where it was found.

We will examine three parts of the beetle: the back legs, the wings, and the mouth. See the

When Scoring Zero Wins

As the pine beetle research shows, climate change will change conditions for the living creatures of the Earth. One way to slow climate change is to reduce the production of carbon dioxide, or CO_2. Carbon dioxide is produced by cars, busses, and any other thing that burns fossil fuels. The Olympic Winter Games of 2002, or any event with many people, requires a lot of vehicles. Can you guess what that means? Right! Lots of carbon dioxide! Planners of the 2002 Games wanted to find a way to keep carbon dioxide emissions from the 2002 Games at zero. It sounds impossible, doesn't it? This is how they did it. Along with using the latest in emissions-reducing technologies, they asked large companies and individuals to reduce their energy consumption equal to the amount the Olympic Winter Games of 2002 would produce.

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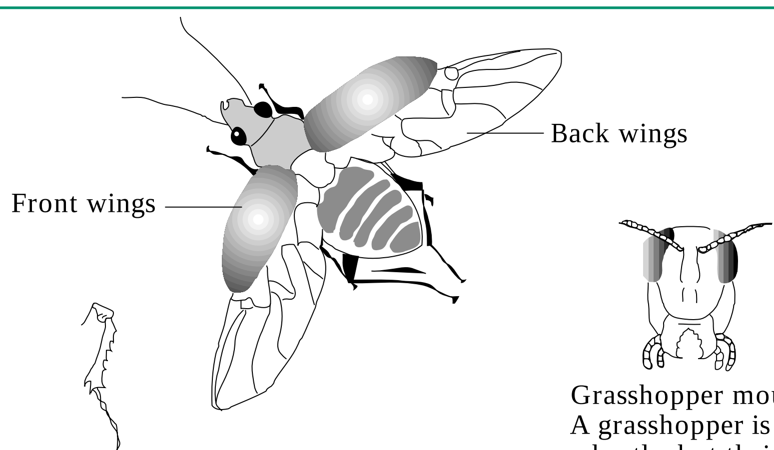
illustrations below and compare them with the beetle you are observing. Let's start with the back legs. Can you see how they are constructed? What do you think the beetle does with its back legs? Beetle legs are designed for digging into wood or soil. Which do you think this beetle digs into? Now look at the wings. Beetles have two sets of wings. The back wings are similar to those of many other flying insects. You may not be able to see the back wings when the beetle is not flying. The most unusual thing about a beetle is its front wings. They are hard, and when folded create a hard shell around the beetle's body. Can you see the hard front wings? What purpose could the hard wings serve? (Hint: Think about what the beetle has to do to get its food or lay its eggs.) Finally, look at the beetle's mouth. A beetle's mouth is made for chewing. Other things that a beetle can do with its mouth are grasp, tear, and crush. Think about the mountain pine beetle. You can see that it is well designed to dig into the bark and phloem of trees.

Now, get a large piece of paper and draw the beetle you are observing. Use crayons to complete the drawing. You may want to focus your drawing on one of the three parts that we examined above. When you have finished drawing the beetle, don't forget to release it back into the same place where you found it!



Grasshopper mouth. A grasshopper is not a beetle, but their mouths look the same.

FACTivity adapted from: Hogan, K. (1994). Eco-Inquiry: *A guide to ecological learning experiences for the upper/elementary/middle grades.* Dubuque, Iowa: Kendall/Hunt. 1-800-228-0810. Reprinted with permission.

From Logan, Jesse A. and Bentz, Barbara J. (1999). Model analysis of mountain pine beetle (Coleoptera: Scolytidae) seasonality. *Environmental Entomology,* 28(6): 924-932.

From Bentz, Barbara J. and Mullins, Don E. (1999). Ecology of mountain pine beetle (Coleoptera: Scolytidae) cold hardening in the Intermountain West. *Environmental Entomology,* 28(4): 577-587.

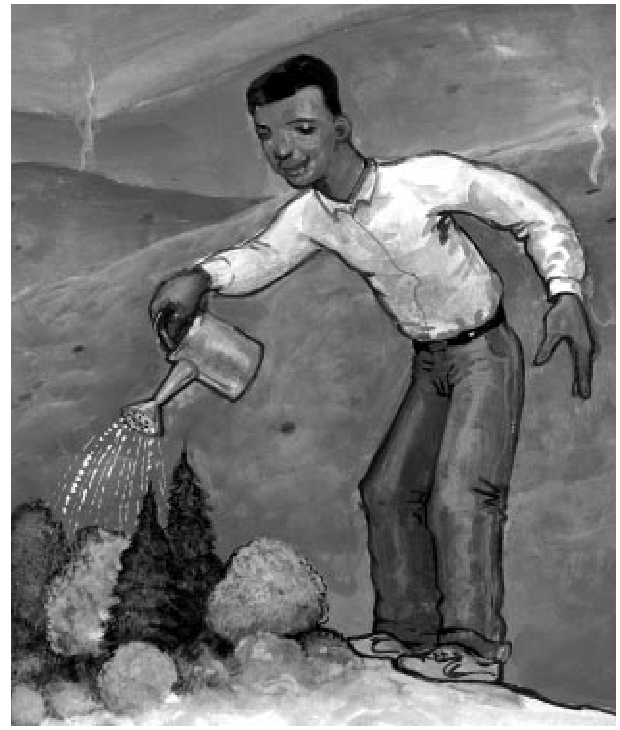
Thank you to Dr. Dan Miller, USDA Forest Service, Southern Research Station, for helping us to understand that mountain pine beetles are sometimes supercool!

Websites:

http://www.usu.edu/~beetle/

Let Nature Take Its Course:

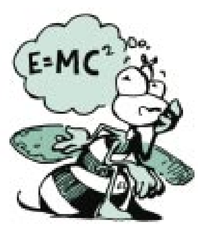
Helping the Environment Take Care of Itself



Meet Dr. Ray Brown:

I like being a scientist because it allows me to follow my passion of learning how nature works, and how we interact with nature. I became interested in natural resources in high school. I had a great biology and science teacher who helped me guide my interests toward where I am today. It always seemed that there was someone to encourage me when I needed it.

Dr. Ray Brown



Thinking About Science

Nature sometimes causes rapid changes, as in landslides, fires, and floods. At other times, nature's change is very slow. Change may take tens, hundreds, or thousands of years. Sometimes, natural resource scientists study natural processes that seem to take a long time, at least from a human perspective. In this study, the scientists wanted to discover how to help nature restore *native* plants to an *alpine* meadow area that had been damaged by human activities in the 1950's. When damage is done to an alpine area, it takes a long time for the land to repair itself. In the 1970's, the scientists began to help nature repair the damage. They recorded their activities and how much the land responded. Their research lasted almost 20 years! You can see that natural resource scientists sometimes need a lot of time and patience to carry out their research.

Thinking About the Environment

The natural environment can be disturbed by natural and human causes. Natural causes include things like wind, fire, and floods. Humans damage the environment by mining, building roads and buildings, and even from recreational activities. Often, the environment can repair itself over time. When the land is severely damaged by human activity, the environment might need help to become healthy again. When *natural resource managers* help the environment, they let nature do most of the work.

They prefer to let native plants restore the land to a healthy state. When native plants are in an area, the area has a better chance of restoring itself as the same kind of *ecosystem* that was damaged in the first place. When a natural ecosystem can become *reestablished*, the environment can resume its own processes and become healthy again.

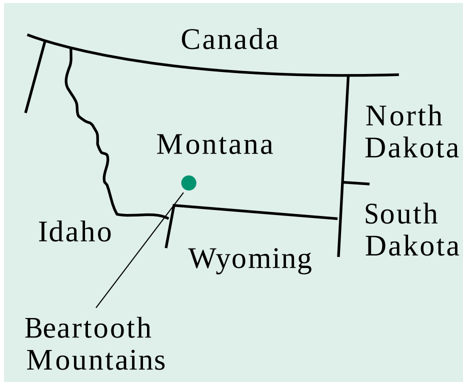


Figure 1. Location of the study area.

Introduction

Until the early 1950's, people mined copper, gold, and silver in the Beartooth mountains in Montana (Figure 1). During mining operations, the soil near the surface was removed before the minerals were taken. All that was left was *mine spoil* (Figures 2 and 3). Mine spoil is highly *acidic*. The acidic spoil *erodes* into waterways and seeps through the land into groundwater, polluting the *watershed* below the mine. Plants cannot grow well on acidic mine spoil. Twenty years after the mining was abandoned, plants had not grown back on the mine spoil. This left an area that could not support any plants or animals, and encouraged *erosion* of the mine spoil into nearby streams.

The scientists in this study wanted to find a way to help reestablish the alpine meadow ecosystem to its pre-mining condition. They hoped that by building the soil and planting a few native plants, normal environmental processes would take over and create a more *diverse* plant community.

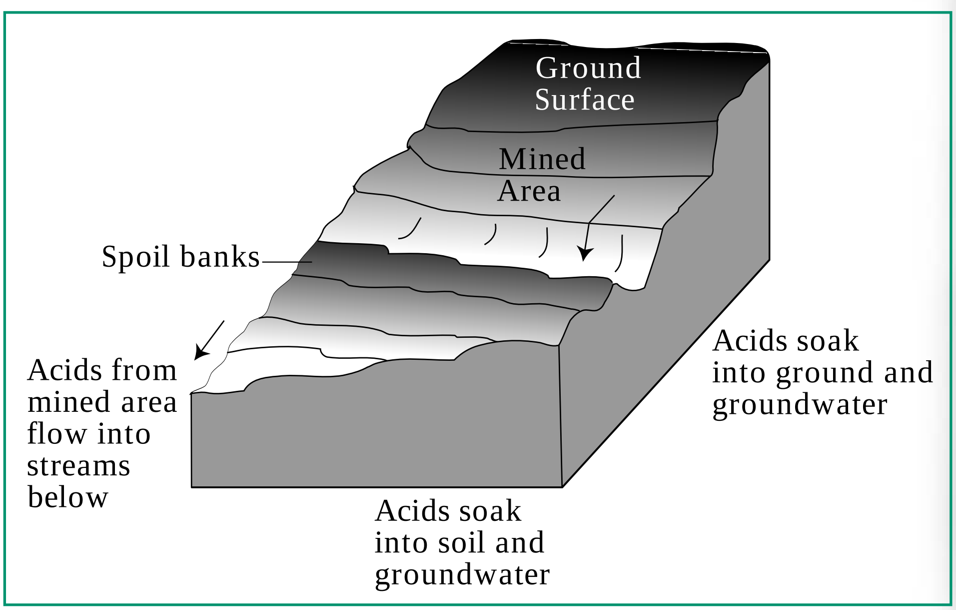


Figure 2. Illustration of mine spoil.

Glossary:

native (**na** tiv): Naturally occurring in an area.

alpine (**al** pin): High mountain area.

natural resource manager (**nach** ur ul **re** sôrs **ma** ni jür): Skilled person who takes care of natural resources.

ecosystem (**e** ko sis tem): Community of plant and animal species interacting with one another and with the non-living environment.

reestablish (re uh **stab** lish): to bring about or establish again.

mine spoil (**min** spoy ul): The waste material left over from mining.

acidic (uh **si** dik): Acid forming (Acid is a substance with a pH less than 7).

erode (e **rod**): To wear away by water or wind.

watershed (**wä** tür shed): Land area that delivers water and sediment to a major river via small streams.

erosion (e **ro** zhun): The process of eroding or wearing away slowly.

diverse (di **vürs**): Differing from one another.

manure (meh noor): Animal waste products.

organic (ôr **geh** nik): Related to or coming from living organisms.

fragile (**fra** jul): Easily destroyed.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

Figure 3. The McLaren mine site in the early 1970's, before Dr. Brown began his research.

Reflection Section

- Why is it important to restore abandoned mining areas to their pre-mining environmental condition?

- If the soil cannot support plant life, what is the first thing that the scientists should do to help the land become healthy again?

Methods

The scientists identified a study area of 1.6 acres (How many hectares is this? Multiple 1.6 by .405.) The scientists bulldozed the 1.6 acres of mine spoil so that it would be close to the original lay of the land (Figure 4). Then, they added lime and steer *manure* to the mine spoil area. They added the lime, which is basic (the opposite of acidic), to raise the pH level to match the pH of other, nondisturbed land in the area (Figure 5). The disadvantage of lime, however, is that it causes *organic* matter to decompose quickly. The scientists used the manure to add extra organic matter to the soil. Then the scientists added fertilizer to the soil.

While they were preparing the soil, the scientists collected seeds from five native grasses and one sedge (a plant similar to a grass). They selected grasses that would have naturally grown in the area before the mining operation. They put the seeds into bags and shook them up, so the different kinds of seeds were mixed together. They planted the seeds in the newly prepared soil (Figure 6). For the next 3 years, they spread more fertilizer over the entire area. In the fourth year, they divided the 1.6 acres into four equal parts.

Figure 4. Bulldozing the mine spoil site.

Figure 6. Planting seeds in the prepared soil.

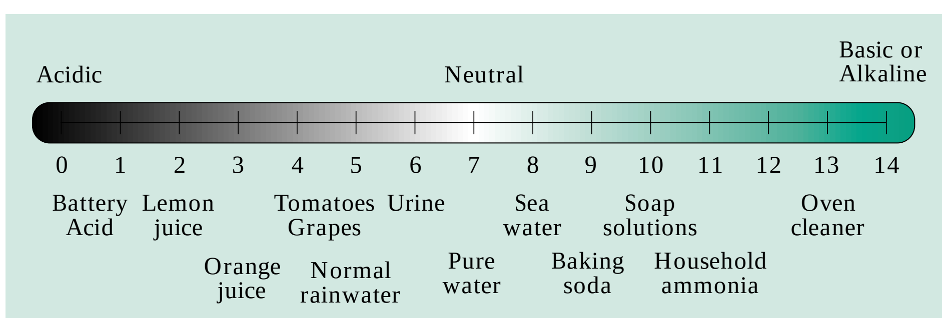


Figure 5. The pH scale.

Each year, they stopped fertilizing one of the four areas. That way, a portion was fertilized every year for 3 years, a portion for 4 years, a portion for 5 years, and one for 6 years (Figure 7). Every year, the scientists identified the species (the type of plant) and the number of individual plants per area growing on the site.

Reflection Section

- What did the scientists want to find out when they divided the area into four portions?
- Why did the scientists select seeds that would have naturally grown in the area?

Results

The scientists found that it did not help to fertilize the soil beyond the first 3 years. They knew this by measuring the growth of the plants and identifying new plants every year. In other words, there was no difference in plant growth between the four portions for the first 6 years (look again at Figure 7). The scientists found that new plant species grew in the area over time (Figures 8 and 9). This was considered a success, since a healthy alpine meadow has a diversity of plant species. The seeds from these new species had come from nearby areas that had native plants growing on them. The seeds were brought into the area by wind, water, and animals. Look closely at Figure 8. The first 6 years did not have much plant diversity. The scientists think that by fertilizing the soil, they were encouraging the growth of the grasses that they planted. The grasses grew thick, and did not allow other species to become established. It was only after fertilization was stopped that other plant species were able to grow. Look at Figure 10 and compare it with Figure 3. These photographs were taken from the same place before the research (Figure 3) and during the research, after plants had begun to grow (Figure 10).

Reflection Section

- Why were other species able to grow after the fertilization treatments were stopped?
- What is the advantage of having a wide diversity of plant species? Think about insects and other animals. Why would a diversity of plant species encourage insects and animals to move into the area?

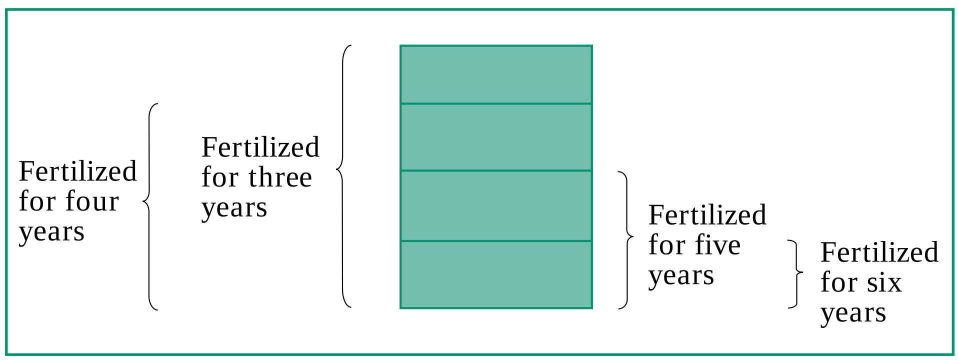


Figure 7. Dividing the land into four areas to test for the effects of fertilizing the soil.

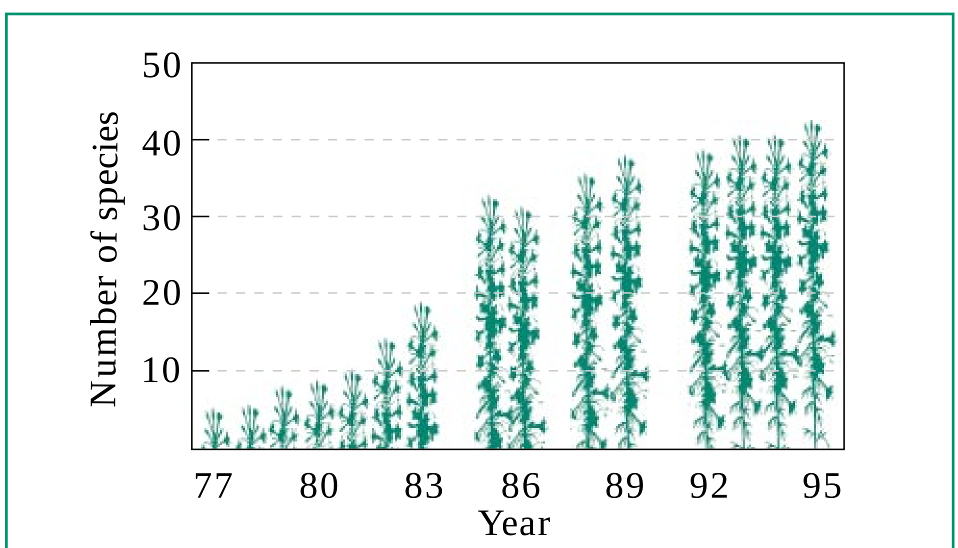


Figure 8. Total number of plant species identified per year.

Figure 9. Plants beginning to grow in the area.

Figure 10. The McLaren mine site after plants began to grow.

Implications

The scientists believe that planting and fertilizing native grasses for the first 3 to 5 years is an important first step to restoring native alpine meadow ecosystems. The grasses help enrich the soil and reduce erosion. After a few years, nature can be left to take its course, and allow a diversity of plants to grow. The scientists recommended that natural resource managers collect native seeds so that they can be used to help repair severely damaged areas. It is important to protect naturally occurring plants near areas that have been disrupted. Some areas, such as old mining sites, need help from managers to become reestablished. However, managers should always use native vegetation, and should let nature do most of the work.

Reflection Section

- Describe another situation where people can help nature take its own course. (Hint: Does your school have an area that was planted for wildlife?)

- Why is the restored natural area preferred over mine spoil? What are the benefits of restoring the natural area? What are the disadvantages of the mine spoil?

FACTivity

In this FACTivity, you will compare two different kinds of soil.

You will need to get two shallow cardboard boxes that are about 16 inches long on each side. Your teacher may need to cut the boxes so that they are about 10” deep and open on the top. Dig up two different kinds of soil, along with the plants growing in the soil. Dig up squares about 15 inches on a side so they will fit into the boxes. Try to dig into the soil at least 3 inches. One kind of soil should be from your school yard or an area where grass is growing. The other should be from a wooded area that has some plants growing in the soil, but this area should not have grass.

First, dig a piece out of each soil block, enough to fill half of a 16-ounce mayonaise jar

Oh Say Can You Seed?

Many of the natural areas used for the 2002 Games are *fragile*. This is especially true in the high mountain areas. This means that any damage done to them will take a long time to repair. The 2002 Games planners wanted to protect these areas as much as possible. They also wanted to repair them quickly after the athletic events were over. They asked Dr. Brown, the scientist in this article, to help them. Dr. Brown suggested that they save the topsoil that was removed and collect native seeds for planting when the 2002 Games were over. Dr. Brown showed the 2002 Games planners how to work with the natural environment. By doing so, the natural areas are protected for future generations.

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(with lid). Do not include the green plants. Put one type of soil in each jar. Fill the jars with water. Close the lids and shake the jars. Label the jars "Soil from wooded area" and "Soil from grassy area." Set the jars aside.

Now, observe the soil and plants in each box. Count the number of different kinds of plants in each box. Can you find any insects? Count the number of insects you find in each box. What other observations can you make about each sample of soil? Make a chart for each box (see an example below). After 30 minutes, examine the jars. Organic material will be a very dark layer floating on or near the top of the water. Without disturbing the jars, measure the amount of organic matter in each jar using a ruler.

	Soil from Grassy Area	Soil from Wooded Area
Number of different plants		
Number of insects		
Other observations (different colors)		
Other observations (other objects found)		
Other observations		
Amount of organic matter (in inches)		

Sample Chart for Soil Observation

Which box of soil is more diverse? Which soil has more organic matter? Why? You have learned in this article that soil with more organic material will be more diverse than soil with less organic matter. Is that true of the soil samples you have observed?

Alternative activities—Select two or more areas of soil to study outdoors. You may also bring in soil samples from home; the amount of organic matter can be measured in soil from many different areas.

FACTivity adapted from: Hogan, K. (1994). *Eco-Inquiry: A guide to ecological learning experiences for the upper/elementary/middle grades*. Dubuque, Iowa: Kendall/Hunt. 1-800-228-0810. Reprinted with permission.

From Brown, Ray W.; Amacher, Michael C.; Williams, Bryan D.; Mueggler, Walter F.; and Kotuby-Amacher, Janice. Ecological restoration of acidic mine spoils at high elevations: Long-term significance of revegetation and natural succession. In: W. R. Keammerer (Ed.). Proceedings: *High Altitude Revegetation Workshop No. 12*, June 1996. *Colorado Water Resources Research Institute, Information Series (No. 83)*. Colorado State University.

Website:

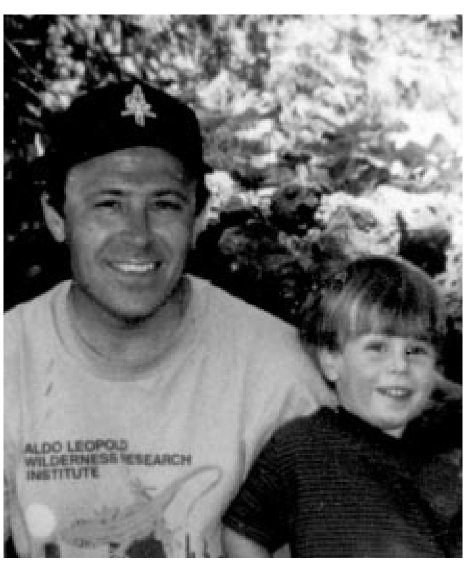
http://www.fs.fed.us/rm/logan/4301/

What Is the Impact of the Impact Monster?

Evaluating Environmental Education Programs

Meet Dr. Bill Hendricks:

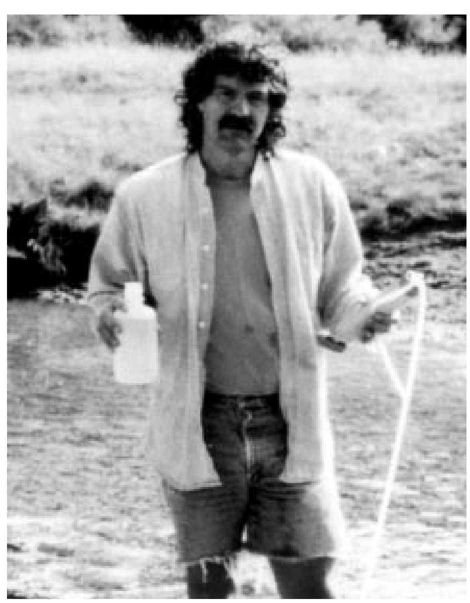
I like being a scientist because I can uncover answers to complex questions. I became interested in natural resources as a child when my family spent time in a park or a forest.



Dr. Bill Hendricks with his son, Sam

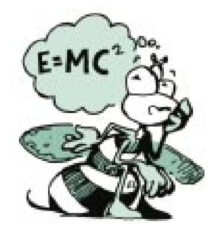
Meet Dr. Alan Watson:

I like being a scientist because I'm helping to keep something special for future Americans. I became interested in natural resources when I was a kid and my family used to visit my uncle and aunt's farm near Elgin, Kansas. We ran free and wild there and learned about nature.



Dr. Alan Watson

Thinking About Science



When teachers teach something, they and others want to know whether their lessons are worthwhile. There is a branch of science called evaluation (e **val** yoo a shen). Evaluation enables scientists to determine the value, worth, or condition of something. When evaluation is applied to education, it helps teachers discover how well they are teaching students. Test-taking is one kind of evaluation. You know that tests help teachers and others determine how much you have learned. But do you know what else test-taking does? It helps the teacher determine how well he or she is teaching! In this study, the scientists took a different approach.

They asked the teachers for information. It was like the teachers were taking a test, except that they were not graded, and there were no right or wrong answers. Now that's our kind of test!

Thinking About the Environment

In this study, the scientists wanted to evaluate a lesson about wilderness. When we call an area of land a wilderness, it means we have given it a special *legal* status. Wilderness areas are treated differently than other land areas. They are protected by law from most human activities, except for fun things like camping, hiking, canoeing, and *backpacking*, and for scientific activities. People are not allowed to live in wilderness areas. They can only be visitors for a short period of time. Plus, people are mostly not allowed to use any motorized equipment in wilderness areas. When people visit a wilderness area, it is as if they are stepping back in time to visit the land as it was before humans made much of an impact (Figure 1). Wilderness areas provide recreational opportunities and the opportunity for people to see nature that has not been disturbed by humans. These areas also help people by preserving *biodiversity* and unique *ecosystems* and providing clean water and air, homes for wildlife and *endangered species*, and an area for scientists to study nature that has not been disturbed by humans.

Introduction

When people visit a wilderness, they should protect it as much as possible. *Wilderness managers* often use education to teach people how to behave

Figure 1. Eagle Creek Wilderness – An example of a wilderness area.

Glossary

legal (**le** gul): Relating to law.

backpacking (**bak** pak *ing*): Camping by carrying food and equipment on one's back.

biodiversity (**bi** o duh **vür** suh te): A measure of the differences between the types and numbers of living things in a natural area.

ecosystems (**e** ko sis temz): Community of plants and animals interacting with each other and with the nonliving environment.

endangered species (en **dan** jürd **spe** sez): Wild plants or animals with so few individual survivors that the species could become extinct in the area where it naturally lives.

wilderness manager (**wil** der nes **ma** ni jür): A skilled individual who manages a wilderness area.

survey (**sür** va): A method used to ask questions to collect information.

associated (uh **so** she a ted): Closely connected with another.

facility (fuh **sil** uh te): A building or room for some activity.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

when they visit a wilderness area. One of the ways students learn about how to behave when they visit a wilderness area is through a special skit. The skit is called the Impact Monster Skit. Although this skit has been used for years, no one had asked the people who used it what they thought about it. Wilderness managers did not know whether it needed to be improved. The scientists in this study wanted to evaluate the Impact Monster Skit by asking people questions about it. (Remember, some tests are not graded!) The scientists wanted to discover three things:

1. Is the Impact Monster Skit an effective way to learn how to behave in wilderness areas?
2. Which age groups learn the most from the skit?
3. What are some problems with the skit, and how can it be improved?

Reflection Section

- If you were the scientist, how would you find out what people think about the Impact Monster Skit?

- The Impact Monster Skit is one way to teach kids how to behave in wilderness areas. What are some other ways that kids could learn how to behave in wilderness areas?

The Impact Monster Skit

The Impact Monster Skit is like a short play that teaches people how to behave in areas like wilderness. In the skit, people pretend to go hiking in an area that is like a wilderness area. During their hike, they meet an Impact Monster (Figure 2). The Impact Monster leaves litter on the trail, picks wild flowers, and does other things that harm the natural environment. The Impact Monster and the hikers learn how these actions hurt the environment. They learn how to behave in such a way as to protect the natural environment. Visit http://www.wilderness.net/carhart/manual/k-8/04K-8.PDF, pages 42-45 of the PDF file.

Figure 2. Students meet the Impact Monster.

Methods

The scientists collected their information by sending a written *survey* to 83 teachers who have used the Impact Monster Skit. Most of the people who responded to the survey were not actually school teachers, but were people who work for the Forest Service (you can read about the Forest Service on the back of this journal, or go to the *The Natural Inquirer* web page at www.naturalinquirer.usda.gov). Sometimes, Forest Service employees went into schools to present the Impact Monster Skit. They also taught other groups of kids, like Boy Scouts and Girl Scouts.

Surveys are like tests, but there are no right or wrong answers. On the survey, the Forest Service teachers were asked these four things:

1. How often did you present the Impact Monster Skit and where did you present it?
2. To what age groups did you present the skit?

3. How well did the skit teach kids how to behave in wilderness areas?
4. What problems did you have when you used the skit?

Reflection Section

- Can you think of other ways that surveys are used in society? Think about what you hear in the news. For example, "The latest survey (or poll) shows that...."

- The scientists asked questions of people who presented the Impact Monster Skit to students. Who else could they ask about the effectiveness of the skit?

Results

Fifty-five people responded to the survey. According to those 55 responses, the Impact Monster Skit was used most often in schools. Table 1 shows the settings where the Impact Monster Skit was used.

The Impact Monster Skit was presented to students from kindergarten through high school. The skit was ranked as most effective for fourth, fifth, third, and sixth grade, in that order. Table 2 presents how many people thought the Impact Monster Skit was effective.

The last question looked at problems encountered when presenting the Impact Monster Skit. The most frequently stated problems were students being afraid of the toy weapon used in the skit, Forest Service teachers getting tired of presenting the skit, and students thinking it would be cool to be like the Impact Monster rather than as a person who takes care of the wilderness.

Location	Number of people who said they presented at that location	Percent of people who said they presented at that location
Schools	43	78.18
Forest Service training session	34	61.81
Campfire programs	25	45.45
Teacher training workshops	19	34.54
Cub/Boy Scouts	19	34.54
Environmental education camps	16	29.10
Girl Scouts/campfires	14	25.45
Church	12	21.81
Leave No Trace training courses	11	20.00
Local fairs	10	18.18

Table 1. Impact Monster Skit locations.

Rating	Frequency	Percent
Excellent	9	16.4
Very good	22	40.0
Good	13	23.6
Fair	8	14.5
Poor	3	5.5

Table 2. Overall program effectiveness of the Impact Monster Skit.

Reflection Section

- Look at Table 1. Where did Forest Service teachers present the skit most often?

- Do you think it is important to learn about wilderness? Why or why not?

Implications

Based partly on the results of this survey, the toy weapon is no longer used in the Impact Monster Skit. The results also show that the Impact Monster Skit should be presented mostly to students in grades 3-6. Teachers presenting the program may avoid getting tired of it by getting the students more involved and by making changes in the program to include local types of plants and animals. By evaluating educational programs such as the Impact Monster Skit, you can see that these programs can be improved.

Reflection Section

- Do you think your teacher can tell how well you are learning without asking you? Why or why not?
- In what ways does your teacher determine how effective a particular program is in your classroom?

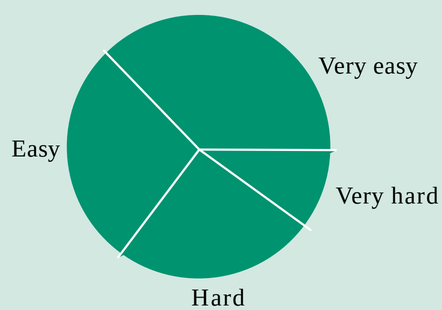
FACTivity

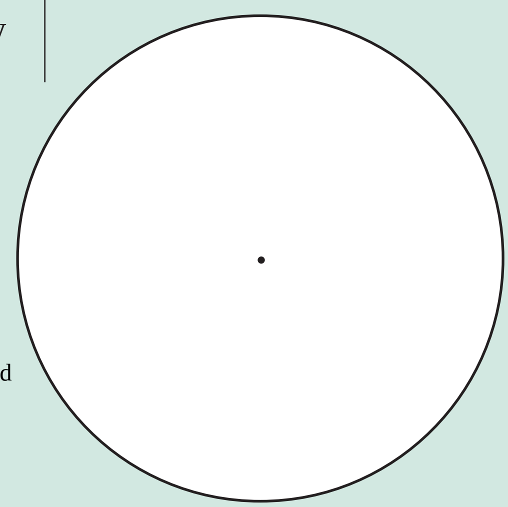
You have learned how important it is to evaluate education programs. Now you will have a chance to do it! You can either evaluate this article or another article from *The Natural Inquirer.* All students in your class must evaluate the same article. Have your teacher copy the student evaluation form on page 49 (or if you are on the website, go to the "Student's Corner"). Every student should have a copy of and complete this evaluation form. Once everyone has completed the form, it's time to summarize the results. When you summarize, you take all of the information collected from everyone and reduce it to a single number. Why do you think you need to reduce it? It would take a long time to present each student's response to each question. Instead, you calculate a class summary for each question.

Begin with question #2. Ask a student volunteer to write the class' responses on the blackboard. Count how many students answered each of the choices in question 2. Then,

You can create a pie chart from Table 2. A pie chart is a circle, and each section looks like a slice of the pie. A pie chart is a way of showing the relationship between values. The pie slices will be different sizes depending on the value *associated* with each slice. You will need a protractor to create your pie chart. Before you start, you need to know that every circle contains 360°. The circle and the dot have already been supplied. Draw a line from the dot to any place on the circle. This is your starting point. You can see that the rating of excellent will take up 16.4 percent of the circle. Multiply 360° by .164 (why should you use .164?). The answer is 59.04°. Use the protractor to mark 59.04° from your starting line. You may not be able to get it exact, but that is okay. Draw a line from the center dot to the outside of the circle to create a pie slice that is 16.4 percent of the circle. If you do this for each value, you will fill up the circle with pie slices of different sizes. Each slice represents one of the ratings. Color the pie slices different colors. Label your pie chart by writing down the rating each slice represents (for example, "excellent" and "very good").

Sample pie chart





The other 3 R's

To provide a place for the athletes to compete, 2002 Games planners had to build some new *facilities* in the natural areas surrounding Salt Lake City, Utah. The 2002 Games planners knew that mountainous natural areas could be easily damaged by people. Therefore, they did many things to protect the natural environment. Can you think of one of the ways they protected the environment? Here's a hint: You are holding it in your hands right now! (Or, you might be looking at it on a computer screen!) That's right! They developed environmental education materials, like *The Natural Inquirer.* When people learn more about a natural area, they can take better care of it. Do you know what the other 3 R's are? Fill in the blanks: Re_ _ _ _, Re_ _ _, and Re_ _ _ _ _.

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you will need to calculate the percentage of the whole class each choice represents. Divide the number of students responding to each question by the total number of students in the class. If there are 25 students in your class and 11 of you said the article was very easy to understand, you will divide 11 by 25, or 25 into 11. The answer is .44, or 44 percent. You can do this with questions 2-9. What kind of change must you make to do this calculation with question 11? You will not be able to do this kind of summary for question 10. Instead, you can list everyone's response. You can make a table for each of the questions 2-9 and for question 11. You can also create a pie chart for each. See the example chart below.

After calculating the responses to these 11 questions and considering your findings, do you think that the article was easy or hard for your classmates to understand? Was it interesting or boring for your classmates? Do you think your classmates learned something from the article? How do you know? What other things can you say about the article, based on this evaluation?

Question 2.

The article was:	Number of students responding	Percentage of Responses
Very interesting to understand		
Easy to understand		
Hard to understand		
Very hard to understand		
TOTAL		100 percent

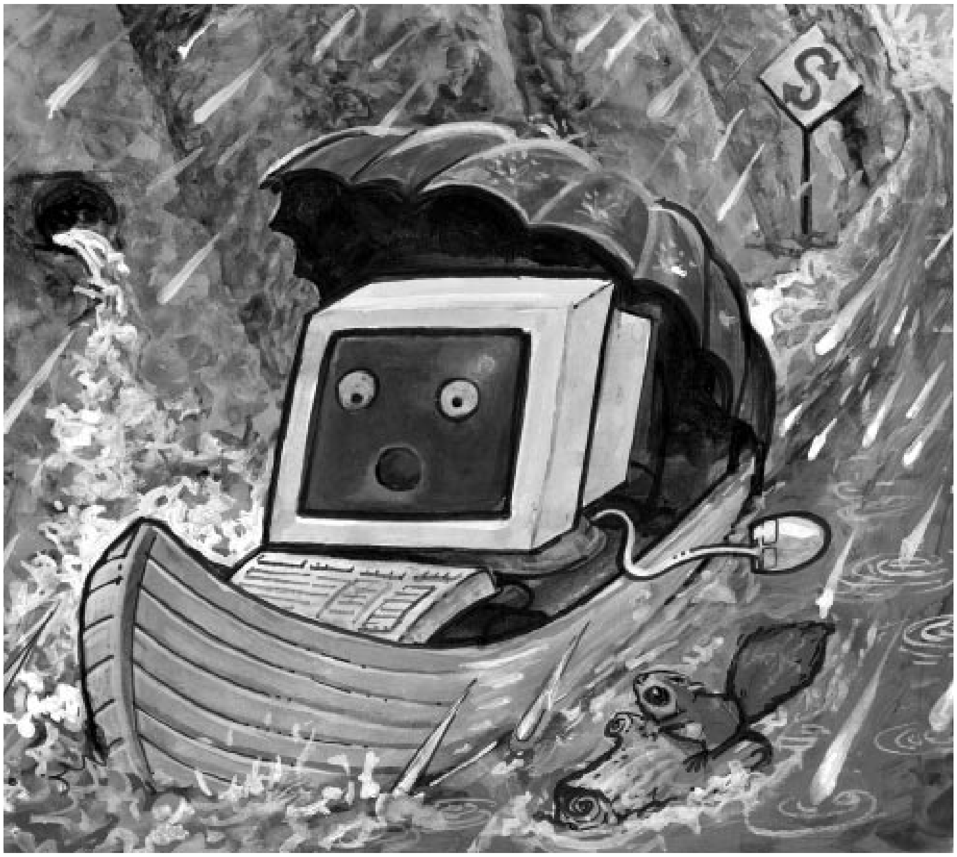
When you have finished this FACTivity, have your teacher collect your forms and send them to Dr. Barbara McDonald, USDA Forest Service, 320 Green St., Athens, GA 30602-2044. Your responses will be added to the responses of students from around the country. Then, all of the responses from around the country will be summarized and listed on *The Natural Inquirer* website.

From Hendricks, William W. and Watson, Alan E. (1999). Wilderness educators' evaluation of the Impact Monster program. *USDA Forest Service Research Paper RMRS-RP-15*.

Website

http://www.wilderness.net/leopold/
http://www.wilderness.net

Should Ditches Be Graded?

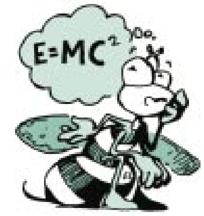


Testing Unpaved Roads With a Computer Program

Meet Dr. Laurie Tysdal:

I like being a scientist because I learned the building blocks of how things work in the natural world around us. And now I can figure out new things on my own, using those building blocks. I became interested in natural resources when I traveled new places and saw plants and rocks and rivers that were different than the ones at home. I wanted to know why.

Dr. Laurie Tysdal



Thinking About Science

For many types of science, an important goal is to be able to predict events that might happen in the future. For example, you know that people try to predict the weather every day! Like the weather, most things in the natural world are so complicated that scientists are not always successful predicting what might happen. With the use of computers, scientists are able to consider the *relationship* of many more *variables* at the same time. With computers, they can study more complicated systems. This is because computers can keep track of millions of bits of information at once. In this study, the scientists compared their actual observations and measurements of *soil erosion* with the *estimates* made by a computer program. They wanted to know how well the computer program could estimate actual soil erosion. If it could estimate soil erosion fairly well, the computer program could become a useful tool for prediction for other places. This is a good example of how science can help society and the environment.

Thinking About the Environment

Whenever humans build something, they

sometimes disturb the natural environment. In forested areas, people often build unpaved roads for occasional use (Figure 1). Even though these roads are useful to humans, they can cause soil erosion and *sedimentation* in the natural environment. This is primarily because rain runs freely across the roads into ditches, carrying soil particles with it. If sediment from roads reaches streams, it can harm the fish or other animals and plants that live in the stream. Scientists want to know how to build roads that do not cause sediment to reach forest streams. Because people want to use these kinds of roads, scientists are looking for ways to design roads that minimize soil erosion and sedimentation. Whenever humans build something, it is always wise to look for ways to reduce harm to the environment.

Introduction

Although it may not seem like it, the way water runs across and down an unpaved, *insloping* road is complex (Figures 2 and 3). Things affecting it include the length of the road, the steepness of the road, the type of soil, the *cutslope*, the steepness of the inslope, the ditch, and the *culvert* (Figures 2 and 3). All of these variables also affect how much soil erosion and sedimentation occurs. Soil erosion and sedimentation reduce the diversity of the natural environment. When soil is eroded and sedimentation occurs, important nutrients are carried away from the soil. The nutrients and sediments eventually run into streams and rivers. When sediment flows into streams and rivers, it can

Figure 1. An unpaved mountain road.

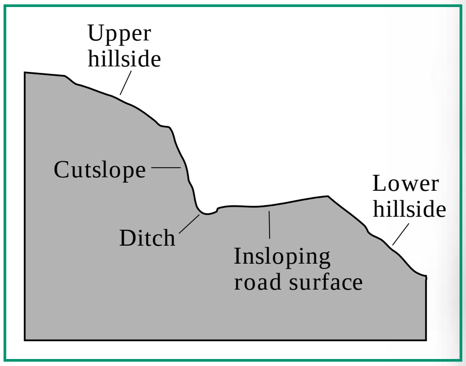


Figure 2. Cutaway view of insloping road.

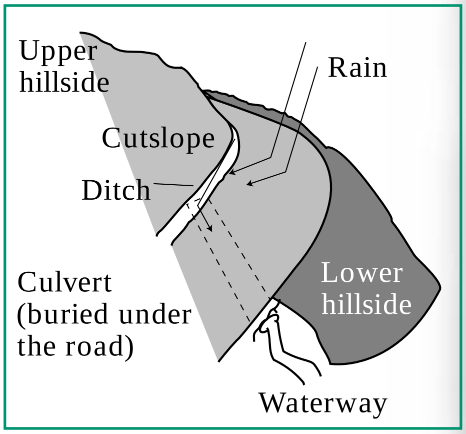


Figure 3. Illustration of insloping road.

Glossary

relationship (re **la** shen ship): When two or more things are connected in some fashion.

variables (**ver** e uh buls): Things that can vary in number or amount.

soil erosion (**soy** ul e **ro** zhun): Movement of soil from one place to another, usually by wind or water.

estimates (**es** tuh mets): Calculated values that come close to the actual value.

sedimentation (se **duh** men **ta** shen): The process of depositing soil and other particles carried by wind or water.

insloping (**in** slop ing): Hillside road surface that slopes down and in the direction of the uphill slope.

complex (kälm **pleks**): Complicated and having many different relationships.

cutslope (**kut** slop): Uphill soil bank along a hillside road.

culvert (**kul** vürt): A pipe placed under a road.

watershed (**wä** tür shed): Land area with small streams that delivers water and sediment to a larger stream.

data (**da** tuh): Factual or measurement information.

associated (uh **so** she a ted): Closely connected in function.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

affect the animals and plants that live there. For example, sediment can smother the eggs of fish, causing the eggs to die. The scientists in this study wanted to find a way to predict how much erosion would be caused by unpaved roads.

Reflection Section

- Have you seen sheets of water flowing across a paved road during a heavy rain? Do you think the road is causing soil erosion? Why or why not?
- What basic force causes water to run downhill? Do you think there is a way to stop water from running downhill? Why is this important for people who build roads?

Methods

The scientists decided to test a computer program that had been developed for agricultural lands. The computer program was designed to look at an area of cropland as a *watershed*, and to predict how much soil erosion might occur. The scientists decided that an unpaved, insloping road could be considered a watershed also. They selected 74 sections of unpaved road along the mountainous coast of Oregon. From those sections they collected *data* on cutslope height and plant cover, road length and steepness (or grade), and the characteristics of the ditch (look again at Figures 2 and 3). They also collected data on soil erosion. They did this by measuring how much soil had been washed through the culverts and into a collection bucket (Figure 4).

The scientists decided that the computer program could reasonably estimate actual soil erosion. They decided this because the actual amount of soil erosion was close to what the computer program had calculated it would be. Therefore, they were able to use the computer program to determine which road characteristics (see Figures 2 and 3) were *associated* with greater soil erosion. To do this, they developed a number of different combinations of road characteristics and placed numbers describing those characteristics into the computer. For example, they developed combinations that represented roads of different lengths, or combinations that represented roads of different steepness (or grade). They changed only one of the characteristics at a time. That way, they were able to use the computer program to identify which characteristics most affected soil erosion and sedimentation (Figure 5).

Figure 4. Culvert pipe and collection bucket used to measure soil erosion.

Reflection Section

- Why did the scientists use data from real unpaved roads

Figure 5. Computer image of an insloping road.

Hit the Road!

To provide a way for people to reach the downhill ski area for the Salt Lake Games, a mountain road had to be built. As you are learning from reading about insloping mountain roads, a mountain road is a complex thing to build. As they planned the road, the 2002 Games planners discovered that not everyone agreed on the best way or path to build the road. Some people were concerned about the damage that might be done to the natural environment. Instead of arguing, the planners found a better way to build the road. Can you think of what they did? They invited everyone to plan the road together. That way, everyone's opinion was heard. The finished road met everyone's needs. It provided access to the downhill ski area, and it protected natural areas and the wildlife that live there. You can see that working together really works!

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to check the computer program?

- How did the scientists know when a road characteristic affected soil erosion?

Results

From the computer program, the scientists found that longer unpaved roads, and roads with steeper grades cause greater soil erosion. In all cases, the ditch also experienced some soil erosion. Graded ditches (those that are maintained using large machines that smooth and clean them) caused more erosion than ditches that were left alone. Higher cutslopes or those with fewer plants eroded more than lower cutslopes or ones with more plants growing on them. However, cutslopes were not responsible for very much erosion. This is because the soil on cutslopes is better able to absorb water. Most of the water that causes erosion flows across the road and into the ditch. After water flows into the ditch, it flows through a culvert and down the hillside. When it flows down the hillside, it may follow a waterway that is natural or one that humans have created. The scientists found that long waterways cause less sedimentation into streams and rivers below. This is because sediment is left along the waterway as the water flows downhill. If a waterway is short and the water enters a stream quickly, it carries more sediment from the road into the stream.

Reflection Section

- If the unpaved road had not been built, what would have happened to the rain water as it fell into the forest?

- When water runs across an unpaved road in the forest, where does it eventually end up?

Implications

By using a computer program, the scientists were able to better understand how different road characteristics affect the amount of soil erosion and sedimentation. Imagine how difficult it would be to find real unpaved road sections with such a large variety of different characteristics! Even if the scientists could find that many road sections, they would have to observe and measure the amount of erosion on each one. And they could only do that when it was raining! And, their measurements would be different depending on how hard it was raining and for how long the rain fell. You can see how useful a computer program can be. When scientists want to study something very complex, such as soil erosion from unpaved roads, it is helpful to have a computer program. But remember, the scientist must first test the computer program with actual data, to make sure it is accurate.

Reflection Section

- Computer programs can help scientists understand other complex situations. Name three other examples of complex situations in which computer programs might be used.

- Imagine that you are the scientist. What would you tell people who ask you for the best way to design unpaved forest roads? Remember, you can vary some of the characteristics (see Figure 1), but not all of them.

FACTivity

In this FACTivity, you will build your own insloping road! Get two large cardboard boxes about 30 inches square and at least 12 inches high. Your teacher should remove the lid flaps from the boxes. Line the boxes' bottom and sides with plastic. Fill each box about half full with soil.

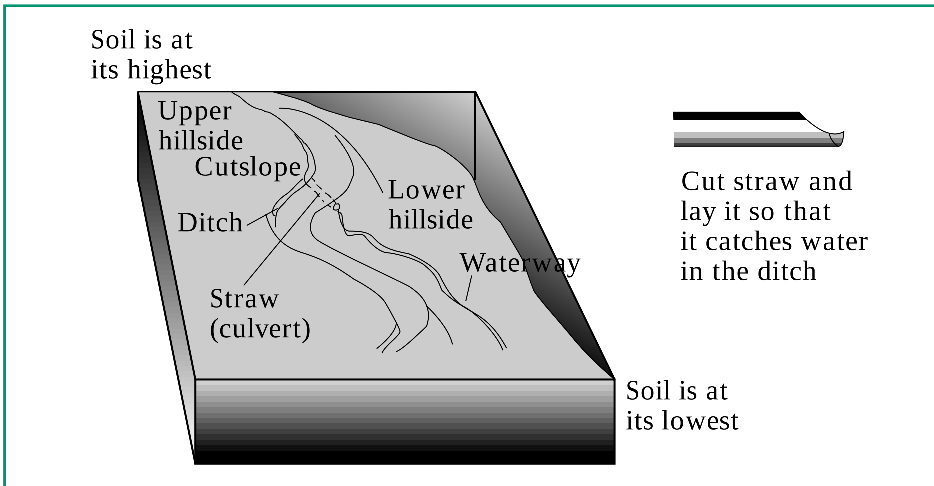
Start by building a "hillside" in each box. The hillside should slope in two directions (see illustration). Now, begin building an insloping mountain road. Remember to slope your road surface inward. Look at Figure 1 in the article for an example. Don't forget to build a ditch on the inside. Use plastic straws for culverts along your road. You will need to cut the edge of the straw before burying it under the road (see illustration). Then, build a waterway from the "culverts" down the hillside by creating ditches down the hillside. The waterways should go down to the lowest corner of the box. In one of the boxes, put plugs of grass (small sections of grass dug up with about 1 inch of soil) on the upper hillside, the cutslope, and the downslope (but not on the road or waterway).

When you have finished building a road in each box, use a watering can to pretend that it is raining. What happens to the water and the soil in each box? Is there a difference in the amount of erosion (soil being carried down the hillside) between the two boxes? Why or why not? What conclusions can you make about the construction of insloping mountain roads? What could you do to reduce erosion for your own insloping road?

From Tysdal, Laurie M.; Elliot, William J.; Luce, Charles H.; and Black, Thomas A. (1999). Modeling erosion from insloping low-volume roads with WEPP watershed model. National Academy Press: *Transportation Research Record*, 2(1652): 250-256.

Website:

http://forest.moscowfsl.wsu.edu/



Goldifinch and the Three Scales:

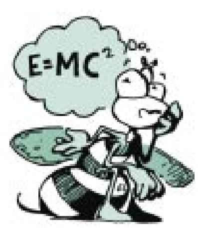
Investigating Songbird Habitats Near Rivers

Meet Dr. Vicki Saab:

I like being a scientist because it is exciting to discover new information about our natural world and to solve problems that will help save animals and plants from *extinction*.

Dr. Vicki Saab

Thinking About Science



Scientists who study *ecology* are called ecologists. Ecologists study the natural environment at different *habitat scales*, often focusing on studying a large area so that they can better understand how plants, animals, and the land interact. Scientists may also focus on a small scale, as when they study the habitat in the immediate natural area where an animal lives. In this study, the scientist was interested in comparing different sizes, or

Glossary

extinction (ek **stingk** shen): No longer existing.

ecology (e **käl** uh je): The study of the interactions of living things with one another and with their environment.

habitat (**ha** buh tat): The environment where a plant or animal normally grows and lives.

scale (sca(uh)l): When you observe something close up or far away, you are observing at different scales.

species diversity (**spe** sez duh **vür** suh te): Number of different types of plants or animals in an area.

biodiversity (**bi** o duh **vür** suh te): A measure of the differences between the types and numbers of living things in a natural area.

species (**spe** sez): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

native (**na** tiv): Naturally occurring in an area.

nonnative (nän **na** tiv): Not naturally occurring in an area.

dependent (de **pen** dunt): Relying on.

cottonwood (**kä** ten wood): A type of poplar tree that has seeds with cottony hairs.

hectare (**hek** tär): A metric measure of land area equal to .405 acre.

landscape (**land** scap): All of the land forms of a region.

relationship (re **la** shen ship): When two or more things are connected in some fashion.

wetland (**wet** land): Area of land with lots of soil moisture.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

scales, of songbird habitat, so that she could better understand which kinds of natural places songbirds prefer to live.

Thinking About the Environment

Species diversity is a particular kind of *biodiversity*. Species diversity is a measure of how many different kinds of *species* live in an area and the numbers of each species. For a natural area to be healthy, it should have many different forms of life. It is best when those species are *native* to the area. When *nonnative* species move into an area, they sometimes compete with the native species for food and homes. An example of a nonnative bird is the brown-headed cowbird. The scientist in this study was interested in the diversity of native songbird species living in riparian forests. Riparian forests are forests located on or near the banks of waterways. Dr. Saab wondered whether nonnative bird species were moving into the forests. If they were moving into the forests, they might be pushing native songbirds out. This would reduce the songbird species diversity. She thought that agriculture and home building on the land surrounding the forests might be creating habitats more favorable for nonnative bird species.

Introduction

Some scientists think that wildlife is mostly *dependent* on the immediate natural area in which it lives. Dr. Saab was interested in exploring this idea, because she thought that native songbirds might also be affected by the larger environment surrounding their immediate forest home. She decided to study areas of land on either side of the South Fork of the Snake River in southeastern Idaho (Figure 1). In the past, large riparian *cottonwood* forests grew along the river (Figure 2). Now only small patches of forest remain. In addition to more natural areas, agricultural land and houses and yards are now found beside the forests (Figure 3). Dr. Saab wanted to know whether the types of songbird species were different in forests with different surroundings. If the type of bird species was the same regardless of the type of land outside of the forest, she would conclude that bird species are mostly dependent on their immediate natural environment, and not on the larger environment outside of their immediate forest home.

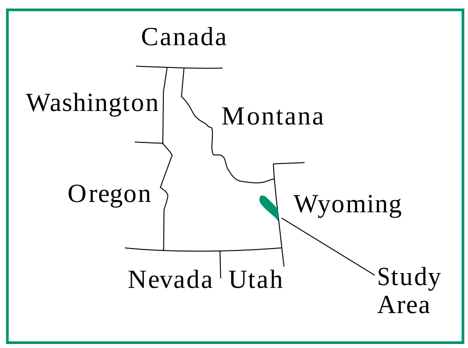


Figure 1. Location of the study area—The South Fork of the Snake River, Idaho.

Figure 2. Cottonwood tree.

Reflection Section

- If Dr. Saab finds that different types of songbird species are nesting in forest areas with different types of surroundings, what should she conclude about songbirds' dependency on natural environments?

- If you were the scientist, how would you find out what kinds of songbirds live in the riparian cottonwood forests along the South Fork of the Snake River?

Methods

Dr. Saab divided the natural areas into three categories of songbird habitat. She called the smallest area a *micro*habitat (as in microcomputer, meaning small computer). The microhabitat included the

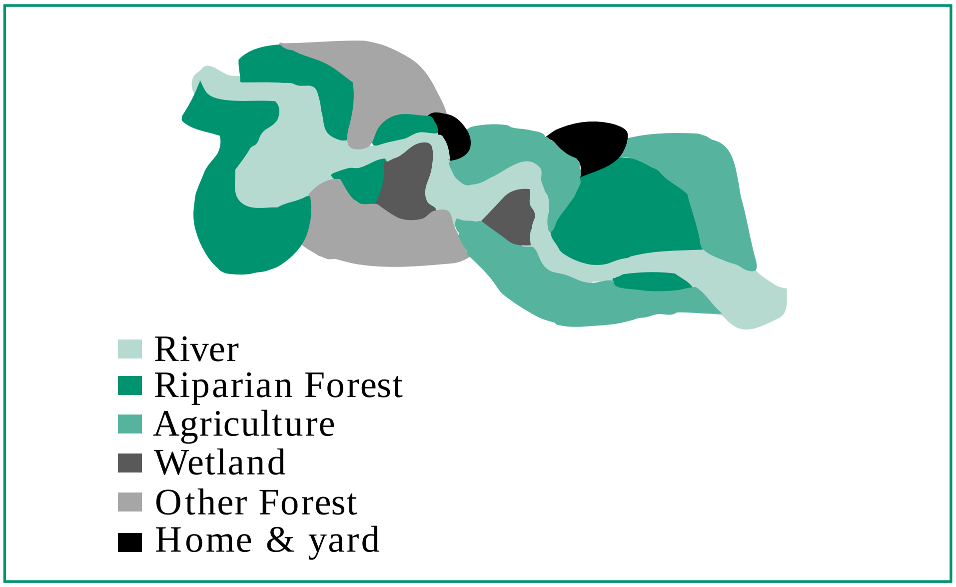


Figure 3. Types of land around the South Fork of the Snake River.

trees, shrubs, and other plants within a small area of cottonwood forest. She called the cottonwood forests macrohabitats, and measured their size (in *hectares*). Dr. Saab called the microhabitat, the macrohabitat, and the land beside it a *landscape* (Figure 4). The landscape might have included houses and yards, croplands, wetlands, and different kinds of forests that were found beside the cottonwood forests, as well as the cottonwood forest itself. Dr. Saab identified the type of songbirds in each of the microhabitats of the cottonwood forests. (Remember that a microhabitat is also a part of a macrohabitat and a landscape.) She identified and counted birds by standing at different places within each area, and identifying and counting the birds she saw through a pair of binoculars (Figure 5). She then compared the type of songbird counted in each of the microhabitats with its relationship to the macrohabitat and the landscape.

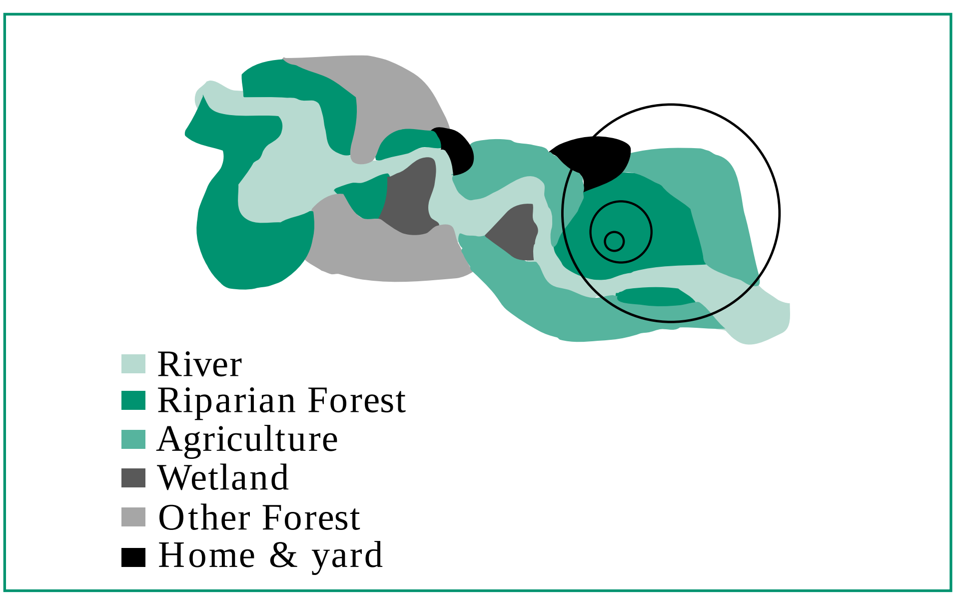


Figure 4. Microhabitat (small circle), macrohabitat (middle circle), and landscape (large circle). Notice that the microhabitat and macrohabitat are completely contained within the riparian forest. Dr. Saab studied many of these sites along the river.

Figure 5. Dr. Saab using a pair of binoculars to look for birds.

Dr. Saab holds a Lazuli bunting after she placed a band on its leg. The band will help her to identify the bird in the future. After placing the band on the bird's leg, Dr. Saab released it back into its habitat along the Snake River.

Reflection Section

- Since all of the bird identification was done in cottonwood forests, do you think that all of the songbird species Dr. Saab identified in each of the microhabitats were the same? Why or why not?
- Why is it important to know whether songbird species are affected by the lands outside of their immediate forest home?

Results

Dr. Saab found that nonnative songbirds were mostly living in cottonwood forests near agricultural and residential lands. These nonnative birds sometimes compete with native songbirds for habitat needs, such as nest sites and food. She found that the greatest diversity of native birds live in cottonwood forests next to natural areas, such as wetlands or other forest areas (not agriculture or residential). Thus, Dr. Saab concluded that landscapes were just as important as microhabitat or macrohabitat for native and nonnative songbirds, meaning that birds of cottonwood forests are dependent on a larger scale of natural area than just their immediate forest home. Dr. Saab found that cottonwood forests cannot support native bird species very well if areas around them are developed into agriculture and residential areas. When homes and farms are introduced, nonnative birds are more likely to move into the forest. Then fewer native songbird species can live in these forests, meaning that overall, native *species diversity* is reduced.

Reflection Section

- Should we be concerned about the loss of native songbirds in natural areas? Why or why not?
- Should we be concerned about the loss of species diversity in natural areas? Why or why not?

Implications

Dr. Saab was interested in looking at different scales when studying the natural environment. In this study, she wanted to know whether the type of land outside the riparian cottonwood forest was important to songbirds living in these forests. If we want to preserve species diversity of songbirds, we should consider natural areas larger than just the forest that is the birds' immediate home.

Reflection Section

- Do you think that the landscape around small forested environments might impact other animals (such as raccoons or snakes) that are found in forested environments? Why or why not?
- What is one thing humans can do to protect the habitat of native animal species in small forested environments?

FACTivity

To better understand songbird habitat, Dr. Saab wanted to look at the big picture. In this FACTivity, we are going to make observations at different scales, just like Dr. Saab. To do this FACTivity, your class will become a spaceship full of Martian scientists. Your spaceship has just landed on Earth. The Martian leader (your teacher!) has asked for a report about the Earth's environment. Some of your class will be "small-scale Martian scientists," some will be "medium-scale Martian scientists," and others will be "large-scale Martian scientists."

The Martian leader should divide your class into three groups, each representing a different scale. The small-scale Martian group should have only two students (remember – small scale!). The medium-scale Martian group should not have more than six students. The large-scale Martian group should include the rest of the students, and should work in teams of six Martian scientists each.

This Is for the Birds!

Salt Lake Games planners needed to find an area to hold the cross-country ski competitions. Many of the places that would be great for the competitions were also perfect for the birds—songbirds, that is! Instead of using the songbirds' home, they found an area that had been used for cattle grazing. They planted *native* trees in the area, and even created a *wetland!* This area became the perfect spot for the cross-country ski competition. Not only that, it is now becoming more and more like a natural area in Utah, and eventually will even become the home for more songbirds.

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Using a large ball of string or twine, the Martian leader should cut one string 36 inches and one 50 feet. Tie the ends of each string together to make two circles with the two strings. After you go outside, place the two string circles on different areas of the ground—the smaller circle should be placed inside the larger circle. The larger circle should include an "edge." An edge defines a change in the environment, such as from a grassy area to a wooded area. It might include the edge of a stream, the edge of a parking lot, a sidewalk, or any other kind of change in the environment. If you are a small-scale Martian scientist, you will explore the small circle. If you are a medium-scale Martian scientist, you will explore the large circle. If you are a large-scale Martian scientist, you will explore the whole schoolyard.

Spend 15 minutes exploring your area and record what you find. You may use the chart below as an example. With other Martians in your group, compare what you found and prepare an oral report to present to the Martian leader and the rest of the class. In this report, you must explain what the schoolyard environment on Earth is like, based on your explorations within your study area.

After the presentations, discuss what each Martian group discovered with the rest of the class. How were the observations similar? How were they different? If the observations were different, why? Which area had the greatest variety of things? Which was the most accurate description of the schoolyard environment? Which was the most difficult to describe? Why? What does this exercise tell you about making observations at different scales?

Sample chart

Which scale? ❑ Small ❑ Medium ❑ Large	
Observations: Record number and description of plants, colors, textures, ground features, insects and other animals, surfaces, etc. You may draw illustrations, record movements. You may record how things feel to the touch. Observe carefully and completely!	

From: Saab, Victoria. (1999). Importance of spatial scale to habitat use by breeding birds in riparian forests: A hierarchical analysis. *Ecological Applications* 9(1): 135-151.

Website:

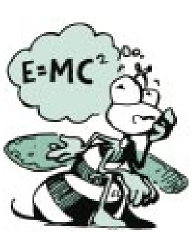
http://www.fs.fed.us/rm/boise/riparian/riparian.htm

Big Fish in a Small Pool:

Habitat Preferences of Cutthroat Trout

Meet Dr. Michael Young:

I like being a scientist because I am fascinated by the natural world. I enjoy the process of discovery, and I want to make sure we *conserve* wild creatures and wild places.



Thinking About Science

For natural resource scientists to be fairly certain about something, they often do many similar research studies. If they get

Dr. Michael Young

similar results in different settings or with different kinds of *species*, they are more confident about their results. The scientists in this study wanted to know where cutthroat trout would prefer to live in a stream, if more *dominant* trout were not present. They removed the largest cutthroat trout from a stream to see what would happen. They expected remaining trout to move into the same locations that larger, more dominant trout had occupied. This study was similar to other studies with other species of trout and other stream fish. In those studies, scientists found that when more dominant fish were removed from a river, other fish moved into their locations. In this way, the scientists thought they could identify the trout's favorite places. What do you think Dr. Young and his colleagues found out about cutthroat trout?

Thinking About the Environment

In the natural world, you might find that two different bird species would like to build their nest in the same place, perhaps a place that is safe from predators. You might also find that members of the same species would like to occupy the same place, such as one that provides a lot of their favorite kind of food. Since there is a limit to the number of individuals one place can support, usually the largest or most dominant individuals of a species get to live in the best places. By studying the preferred location of the dominant individuals, scientists can learn about the best *habitats* for certain species.

Introduction

Cutthroat trout are a type of salmon (Figure 1). Do you know why they are called cutthroat trout? They all have what looks like a "cut," or a patch of orange or red on their throats! Cutthroat trout live in the Western United States, from southeastern Alaska to northern California. The scientists in this study wanted to find out if cutthroat trout behave like other *salmonids*. Other salmonids had been found to swim into preferred locations once more dominant fish had been removed. This helps scientists learn about the favorite locations of these fish. Dr. Young and his colleagues guessed that when they removed the most dominant cutthroat trout from a mountain river, other trout would quickly move into the locations the more dominant fish had occupied.

Figure 1. Cutthroat trout

Glossary

conserve (kän **sürv**): To avoid wasteful or destructive use of something.

species (**spe** sez): Group of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

dominant (**dä** muh nent): Being able to control all others, or being in the majority.

habitat (**ha** buh tat): The environment where a plant or animal naturally grows and lives.

salmonids (**sa** muh nidz): Long, bony fishes such as salmon or trout.

vacant (**va** kunt): Not occupied.

pool (pool): A quiet, deep place in a stream.

riffle (**ri** fül): A shallow place in a stream with fast water and small waves.

fish biologist (fish bi äl uh jist): A person who studies fish and the processes that support fish.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

Reflection Section

- Do people, like some fish, move into a preferred location when one becomes *vacant*? Can you think of an example of when people do or don't do this?

- What would be one problem for scientists trying to study fish in a free-flowing river?

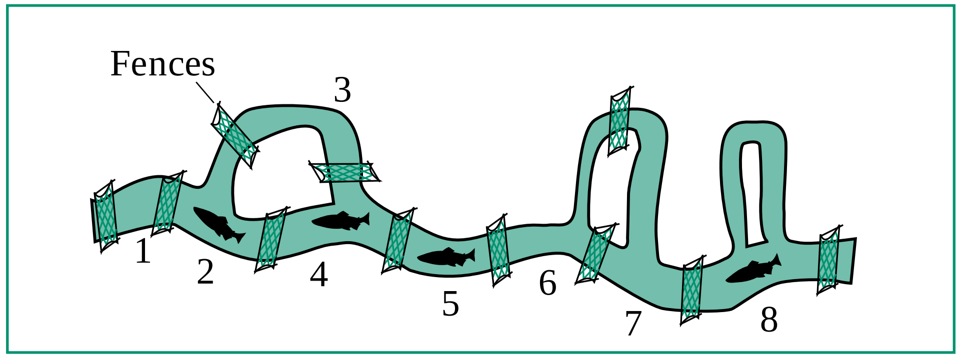


Figure 3. Diagram of stream with fences installed creating eight study sections.

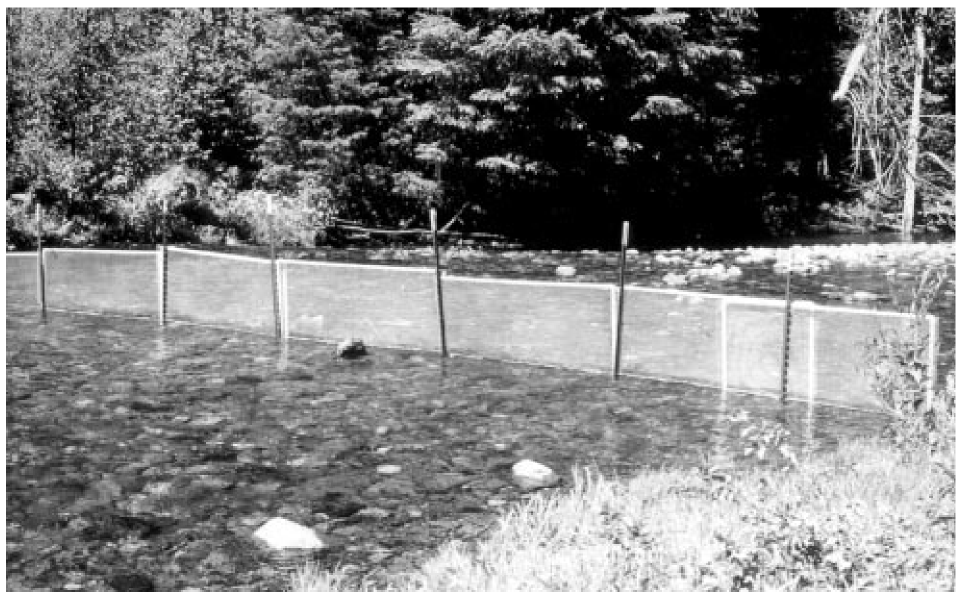


Figure 4. Fence installed in the river.

Methods

Because natural rivers are free flowing, scientists cannot be sure fish will remain in an area while the scientists are studying them. To solve this problem, Dr. Young and his colleagues placed wire fences at various places in the North Fork of the Little Snake River (Figures 2, 3, and 4). They created eight sections to study. They identified the kind of habitat in all of the fenced sections as either *pools* or *riffles*. They removed the largest and most dominant fish from the areas between the fences. Then, they placed one new large cutthroat trout into each fenced section of the river. By creating eight sections, the scientists were able to study the favorite locations of eight new trout.

Fish can be hard to distinguish from one another, and may be especially hard to locate in a mountain river. To keep track of the new trout, the scientists surgically implanted radio transmitters into the trout before releasing them into the fenced sections of the river. They recorded each trout's location and movement for 1 week. They identified whether the new trout preferred pools or riffles, and whether the new trout preferred the same locations as the trout that had been removed (Figure 5).

Figure 2. The North Fork of the Little Snake River.

Reflection Section

- Why do you think it was a good idea to create eight sections to study, instead of just one?

Figure 5. Marking locations in the river.

- The scientists expected the new trout to prefer the same locations as the trout that had been removed. What do you think they found?

Results

Right after they were placed into the river, the new cutthroat trout swam around much more than normal. The scientists think that was because the trout had just been handled by humans. Once the trout became accustomed to their new home, the scientists discovered that most of the trout preferred to swim in pools rather than riffles (Figure 6). This did not surprise the scientists, for they already knew that trout prefer to swim in pools. However, the new trout did not always select the same pools that were selected by the trout that had been removed from the stream sections. This was a surprise to the scientists. It surprised them because other studies had shown something different. Other studies had found that salmonids consistently selected the same pools as their favorite place to swim.

Reflection Section

- What might be some of the reasons the new cutthroat trout did not swim in the same locations as the old cutthroat trout?
- If you were the scientist, what would you conclude from this research?

Implications

The scientists offered three possible explanations for this surprising finding. First, they guessed that new trout did not occupy the same locations as the old trout because they were not familiar with the river and did not know where those preferred locations were. Second, they guessed that cutthroat trout may need more than 1 week to thoroughly explore the advantages and disadvantages of various locations in a river. Third, they guessed that many locations within a river may be equally preferred by trout and not necessarily just those locations preferred by old (removed) trout.

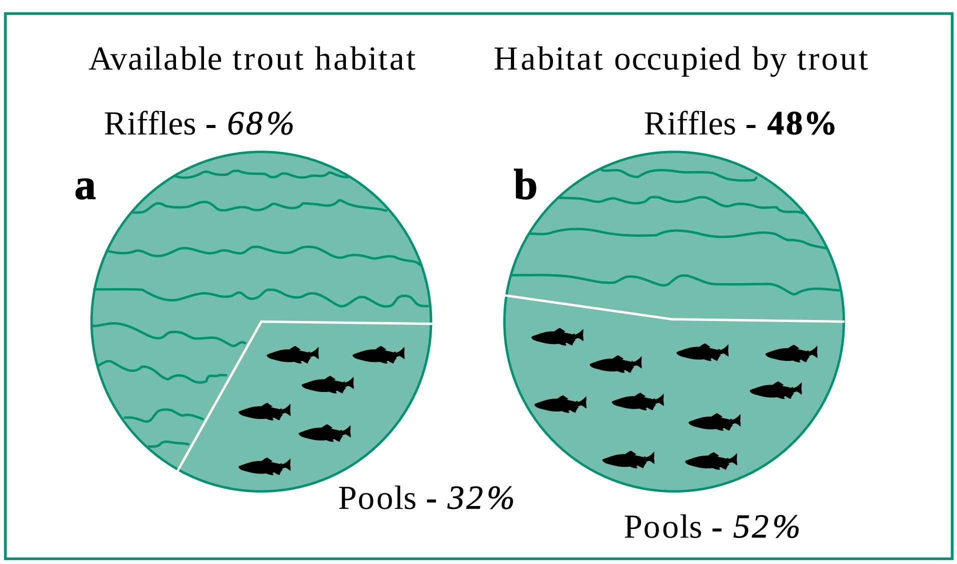


Figure 6. Pie charts showing (a) percentage of available pools and riffles and (b) percentage of trout that occupied pools and riffles.

Fin Trading Is In

The Bonneville cutthroat trout is the State fish of Utah. The trout's habitat is threatened by many disturbances. Many of the locations that would have been perfect to hold the biathlon and nordic combined ski events for the 2002 Games were also areas where streams contained Bonneville cutthroat trout. If these natural areas were developed for the ski events, the trout's habitat would be further disturbed. What do you think might happen to some of Utah's State fish? What do you think the 2002 Games planners decided to do? They did the best thing for the trout and found a site that was great for skiing and wasn't home to any sensitive animal species! By doing it this way, even the trout can win!

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The scientists concluded that natural resource scientists should be careful when they identify some locations as the most preferred habitat for fish. This is especially true when they base that identification on the location of the most dominant fish.

Reflection Section

- Often, natural resource managers change natural resources to create better habitat for a species. What might happen if natural resource scientists incorrectly identify a favorite type of habitat?
- Once this research was finished, what should the scientists have done with the fences they put in the river?

FACTivity

In order to learn about trout habitat, the scientists in this study had to learn how to carefully observe and record their observations. In this FACTivity, you will learn how to improve your observation skills. Bring a natural object for observation, such as a stick, rock, or a leaf to class. Place the item on your desk in front of you. Just sit and observe the item. What color is it? Is it the same color all over? What shape is it? What else can you observe about the item? Write down everything you observe about the item. Use the chart below as a sample. You may have many more than five observations! After you have finished observing your own item, choose another student as a partner to exchange your item with. Repeat your observation using your partner's item.

Compare your observations with those of your partner. How are they similar? How are they different? What does this tell you about observation? Have a class discussion about how observations of the same item can be similar and different. Why do you think observations of the same item may be different for different people?

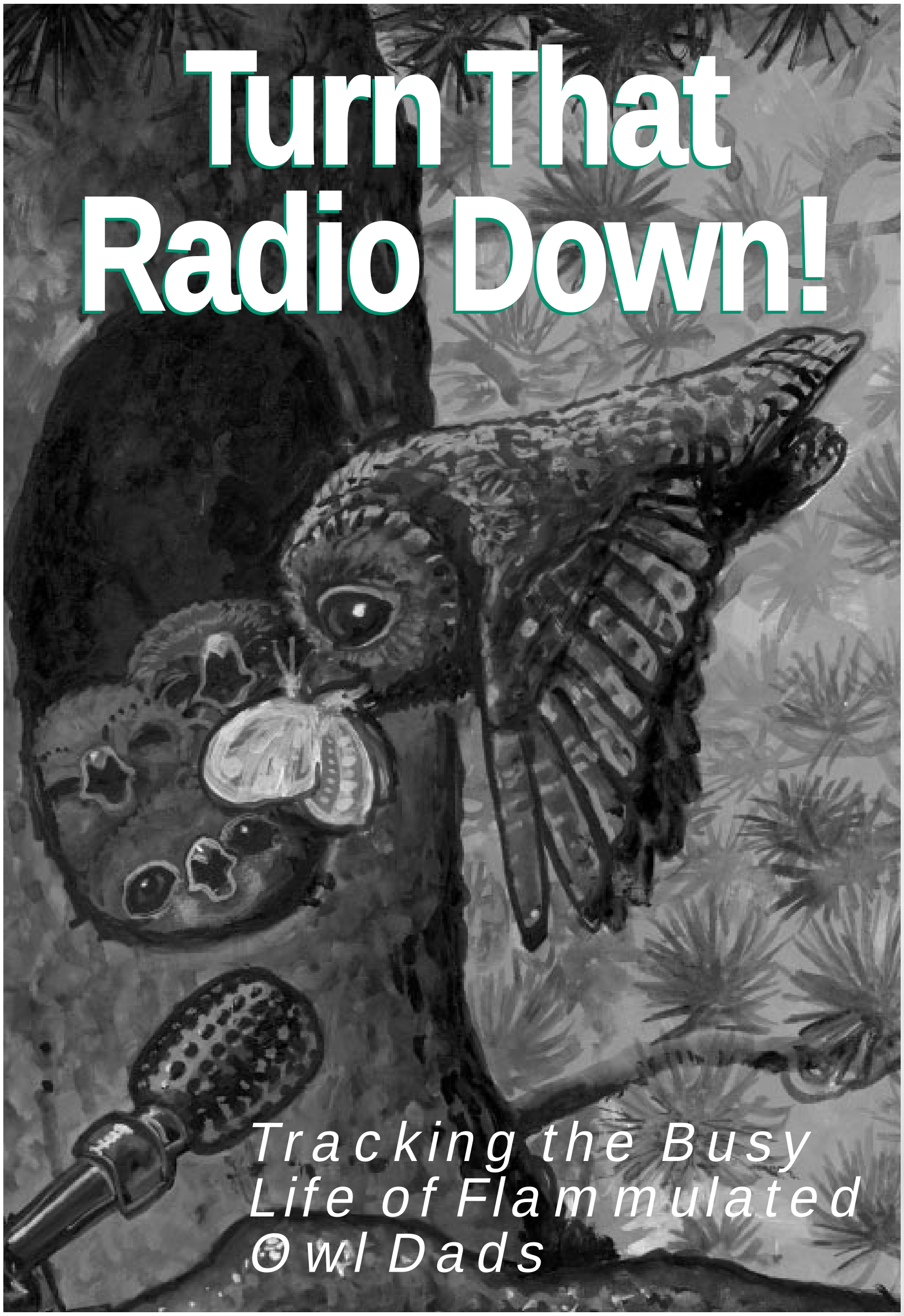
From Young, Michael K.; Meyer, Kevin A; Isaak, Daniel J.; and Wilkison, Richard A. (1998). Habitat selection and movement by individual cutthroat trout in the absence of competitors. *Journal of Freshwater Ecology*, 13(4): 371-378.

Website:

http://www.fs.fed.us/rm/main/labs/laramie/rmrs4352.html

Sample chart for recording observations.

Name of object:	
Observation 1:	
Observation 2:	
Observation 3:	
Observation 4:	
Observation 5:	



Turn That Radio Down!

Tracking the Busy Life of Flammulated Owl Dads

Meet Dr. Brian Linkhart:

I like being a scientist because it's exciting discovering new things about unusual animals, and trying to understand the needs of animals so that we may help ensure their survival in the future. I became interested in natural resources when I began spending a lot of time backpacking and fly fishing in the mountains of Colorado as a young teenager.

Dr. Brian Linkhart

Glossary:

radiotelemetry (**ra** de o tuh **le** muh tre): The process of using radio waves to record the location of animals.

cavity (**ka** vuh te): A hollowed-out space.

conifer (**kä** nuh für): A type of evergreen tree (pine, fir, spruce) that has cones.

nocturnal (**näk** tür nul): Relating to or occurring at night.

habitat (**ha** buh tat): Environment where a plant or animal naturally grows and lives.

breeding habitat (**bre** di*ng* **ha** buh tat): Environment where an animal nests and reproduces as opposed to where it lives during the rest of the year.

population (pop yoo **la** shun): The total number of individuals of a species living in an area.

forage (**for** ij): (1) Food for animals usually taken by browsing or grazing and (2) the act of taking such food.

day-roost (**da** rust): When birds with wings rest or sleep during the day.

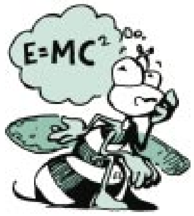
tree crown (tre kroun): The upper green section of a tree with leaves or needles.

wildlife manager (**wi**(**uld**) lif **ma** ni jür): Skilled individual who manages natural resources for wildlife.

forest manager (**for** est **ma** ni jür): Skilled individual who takes care of natural forest resources.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing



Thinking About Science

The development of technology has been helpful to scientists who want to study animals that live in the wild. By using technology, scientists can learn about these animals without harming or interfering with the animals' normal behavior and movements. The scientists in this study used *radiotelemetry* to study the behavior and movements of Flammulated (**fla** mu la ted) owl fathers. Radiotelemetry involves attaching a small electronic transmitter to the animal. The device sends out a signal that is detected by an electronic receiver. The scientist can then identify the location of the animal, even as the animal moves from place to place in its habitat. It is important not to disturb wildlife even when we are trying to learn more about it. Technology helps scientists to do this.

Thinking About the Environment

Flammulated owls make their nests and raise their young in old *conifer* forests (Figure 1). Old forests are forests whose trees have not been cut down or disturbed for hundreds of years. In addition to large living trees, old forests have large numbers of standing dead trees. These dead trees, or

Figure 1. Old conifer forest.

snags, are preferred by owls because they can make their nests in the dead trees' *cavities* (Figure 2). These cavities are usually created by woodpeckers. The needles, limbs, and trunks of old conifers are good places to find insects and spiders, which male Flammulated owls feed to their young. Old forests, as opposed to forests composed

Figure 2. Flammulated owl in a tree cavity.

of younger trees, are better suited to the needs of mother and father Flammulated owls. Without old forests to live in, Flammulated owls would have a hard time finding enough food to feed their young. Old forests need small fires that burn naturally on a periodic basis. When these small fires burn, they keep small brush and young trees from growing too big to compete with the older trees. You can see that there is a relationship between small, naturally occurring forest fires and Flammulated owl babies!

Introduction

When pairs of Flammulated owls get ready to reproduce, they must find a place to build their nest. They need a location convenient to a food supply suitable for baby Flammulated owls. The scientists wanted to know what kind of *habitat* Flammulated owls prefer to use when raising their young. Although the scientists knew generally what kind of forest these owls lived in, they did not know much about the specific area that the owls use to raise their young. They wanted to know what kind of trees were most favored by Flammulated owl parents. Flammulated owls are widespread across the Western United States, but are small and shy, and therefore hard to study. The scientists needed to develop a method to study these owls, but they did not want to disturb the owls while they studied them.

Figure 3. Flammulated owls are shy, nocturnal *small owls, about 6 inches high (smaller than a robin!). Flammulated owls eat mostly insects, capturing them by swooping down and grasping the insects with their talons (claws).*

Reflection Section

- If the preferred *breeding habitat* of Flammulated owls is not available, what might happen to the Flammulated owl *population?*

- What might cause the breeding habitat of Flammulated owls to become unavailable?

Methods

The scientists identified an area to study within a forest in Colorado where they knew Flammulated owls had been seen. For this study, the scientists focused on the behavior of the father owl. Male Flammulated owls are the breadwinners in the family! They gather insects and spiders throughout part of the night and bring them back for the baby owls to eat. The scientists waited until after the mother owl had laid her eggs. Then, male Flammulated owls were briefly captured, outfitted with a radio transmitter, and released. The scientists knew the location of the father owls throughout the day and night because they received radio signals from the transmitters. The scientists identified where the owls were located, then went to that area of the forest to observe the owls in person. They recorded what the owls were doing at the time. They sometimes used flashlights to see the owls and record the owls' behavior.

The scientists classified the father owls' behavior into four activities. These activities were: (1) *Foraging*, (2) Territorial singing, (3) Resting, and (4) *Day-roosting.* When they observed the father owls doing any of these activities, they recorded the activity and the kind of tree in which they found the father owl.

Reflection Section

- Why was it important for the scientists to accurately record the type of tree in which they found the father owl?

- Why did the scientists need flashlights to record much of the owls' behavior?

Results

The scientists were interested in the kinds of trees the father owls used while they were raising their young. While the mother owl was sitting on the nest, the father owl did three kinds of activities during the night: He foraged for food and provided it to the babies, he sang (hoo, hoo, hoo) to establish and defend his territory, and he rested. During the day, the father owl roosted. Table 1 presents the scientists' findings.

From this table, you can see that most of the father owls' activities occurred in Douglas-fir and Ponderosa pine trees. More than half the time, father owls foraged for food in Douglas-fir trees. When father owls sang to establish and defend their territory, they usually sang from the lower part of the *tree crown*, near the trunk. They only sang from Douglas-fir and Ponderosa pine trees. The work of father owls is hard; therefore, they often had to rest after they fed their young. They rested mostly in

Tree species	Percent of all trees available in the study area	Percent Foraging activity	Percent Territorial singing	Percent Resting	Percent Day-roost-ing
Douglas-fir	39	61	50	58	58
Ponderosa pine	29	19	50	35	26
Quaking aspen	17	9	–	1	1
Limber pine	10	6	–	6	9
Blue spruce	5	5	–	–	6
TOTAL PERCENT	100	100	100	100	100

Table 1. Percent of locations identified for each of the four activities according to the type of tree.

Douglas-fir and Ponderosa pine trees. When father owls roosted during the day, they usually selected Douglas-fir and Ponderosa pine trees. The average age of the trees used by father Flammulated owls is shown in Table 2.

The fathers usually fed their babies in the early evening. During that time, they were very busy! They usually made about 16 trips per hour to the nest. (About how many minutes did they spend foraging and delivering each meal?) Each time, they delivered only one small kind of prey, such as a spider or moth. You can see why it is important for owls to build their nests close to their food supply!

Reflection Section

- What kind of trees do Flammulated owl fathers prefer? Why do you think they prefer these trees?

- If you were a *wildlife manager,* what would you do with Douglas-fir and Ponderosa pine forests? How would you balance the needs of the owls with the needs of humans for wood products?

Implications

Father Flammulated owls are usually found in old Douglas-fir/Ponderosa pine forests. In the past, these old trees were protected naturally by frequent, small ground fires. These small fires kept brush and most of the smaller trees from growing up and competing with the larger trees. These naturally occurring small ground fires could not reach the high tree crowns, and the trunks were too big to catch on fire. The fire eventually died out on its own. Then, humans began putting these fires out rather than letting them burn. They did this because they thought they were protecting the forest, and they also wanted to protect houses and other buildings. Putting the fires out, along with cutting the big trees for wood products, has changed some of the old forests. There are no longer as many old trees for Flammulated owls to raise their young.

	Foraging	Territorial singing	Day-roosting
Average age of trees	199 years	289 years	207 years

Table 2. Average age of the trees used by father owls for three activities.

Reflection Section

- We used to think that all forest fires should be put

Whoooo Goes There?

To provide a safe way for people to reach the downhill ski area for the Olympic Winter Games of 2002, a mountain road had to be built. Forest Service biologists studied the area where the road was to be built and discovered several Flammulated owl nests. What do you think they did about this? Could they move the nests? The planners of the road did what was best for the owls. They planned the path of the road around the area of old trees where the owls had made their nests, and they planned the construction of the road around the time that the owls would be nesting. The road was longer, cost more money, and took more time to build because of the changes to protect the owls, but they saved the breeding habitat of an important bird species.

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out. We now know that some kinds of natural fires are good for the forest. In what ways could some natural fires be good for a forest and the animals that live there?

- What should the scientists do with the radio transmitters that they placed on the father owls?

FACTivity

In this FACTivity, we are going to create concept maps. Concept maps are like drawings, but they show how ideas and things are linked together. They usually start with a main idea, and then other ideas are linked by lines that show relationships to each concept. Words are also used to describe those relationships. Words that can be used include:

becomes, includes, make, for, need, is/are, has/have, release, uses, used by, with, shows, from, like, can be, cause, contain, go between, such as, release

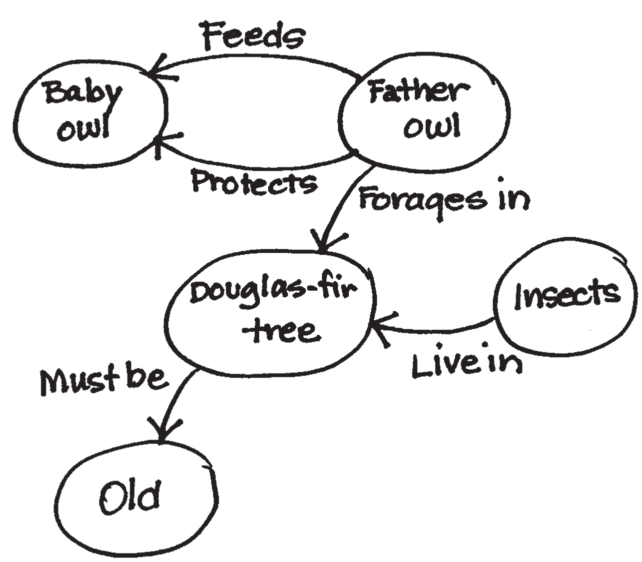
Figure 4 shows the beginning of a concept map for Flammulated owls. It is your job to complete this concept map. You can base your concept map on what you learned from the article, as well as what you already know about owls. Some of the ideas you might add include insects, water, humans, and fire. But don't stop there! Think about all of the things that baby Flammulated owls need to live.

FACTivity adapted from: Hogan, K. (1994). *Eco-Inquiry: A guide to ecological learning experiences for the upper/elementary/middle grades.* Dubuque, Iowa: Kendall/Hunt. 1-800-228-0810. Reprinted with permission.

From Linkhart, Brian D., Reynolds, Richard T., and Ryder, Ronald A. (1998). Home range and habitat of breeding Flammulated owls in Colorado. *Wilson Bulletin,* 110(3): 342-352

Website:

http://www.fs.fed.us/rm/main/labs/flagstaff/rmrs4251.html
For more information on owls, visit www.owlpages.com/

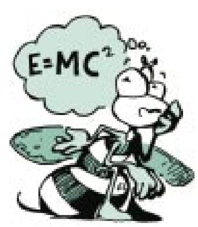


Excuse Me While I Flow My Snows

What Makes an Avalanche Happen?

Meet Dr. Karl Birkeland:

I like being a scientist because I get to play detective. I search for answers to avalanche problems faced by people who work and play in the mountains. I became interested in avalanches in college while I was working as a ski patroller. Being an avalanche scientist combined my love of skiing, mountains, snow, and science.



Thinking About Science

Natural resource scientists help to solve some of society's problems by discovering new information about the environment. Sometimes, just learning new things about the environment helps citizens make better decisions. In this study, the scientists were interested in discovering which weather and snow conditions can create avalanche conditions. This is important because avalanches can be dangerous and even deadly for snow skiers and other people who go into snow-covered mountain areas. If people know which weather conditions are favorable for avalanche formation, they can avoid going into snowy mountain areas during those weather conditions. In ways such as this, the work of natural resource scientists can help people make decisions that keep them safe.

Thinking About the Environment

Avalanches are snow masses that suddenly release and flow down a hillside. Avalanches are most common on steeper slopes, such as those over 30°, and can travel faster than 100 mph (160 km/h) (Figure 1). Even the weight of skiers or other

Dr. Karl Birkeland

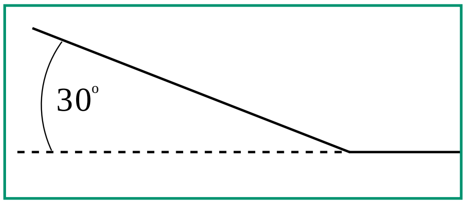


Figure 1. 30° slope.

mountain travelers can trigger avalanches during unstable conditions. Avalanches are one of nature's large-scale forces, similar in *scale* to landslides, floods, and tornadoes. Such large-scale environmental forces usually occur naturally. However, when humans are affected, their impact may be *disastrous* for individuals and society.

Introduction

Slab avalanches are the most dangerous kind of avalanche. A slab is a layer of new snow sitting on top of a layer of snow, called a weak layer. Scientists call this a weak layer because the bonds that hold the snow crystals together are weak. Added weight, such as more new snow, may be piled on top of the weak layer. When this happens, part of the new slab can break off and slide down the mountain. The scientists in this study wanted to learn how the weak layer is formed. Although there had been studies of the formation of other weak layers of snow in other places, no one had studied this particular weak layer in Montana.

Although the scientists knew that these weak layers were being formed, they did not know how snow temperatures are related to this process. Dr. Birkeland and his colleagues conducted this research to better understand the relationship between daytime and nighttime snow temperatures and the formation of the weak layer of snow. They also wanted to observe whether any avalanches were *associated* with the weak layer.

Reflection Section

- The scientists wanted to study the temperature of the snow at its surface and below the surface. If you were the scientist, how would you measure snow temperature at these locations?

- What danger, if any, did the scientists face when they conducted their research? How do you think they reduced the danger to themselves?

Methods

The scientists wanted to measure snow temperature at the surface and down to 20 centimeters into the snow. (How many inches is this? Multiply 20 by .394 to find out!) They measured the snow temperature by glueing thermometers along a plastic pipe. They protected each thermometer by placing all but its end in a stainless steel tube before glueing it to the pipe. They glued two thermometers to the top end of the pipe, 1

Glossary:

scale (sca(uh)l: When you observe something close up or far away, you are observing at different scales.

disastrous (di **zas** trus): Causing suffering or disaster.

associated (uh **so** she a ted): Closely connected with another.

relationship (re **la** shen ship): Being related or connected.

water vapor pressure (**wä** tür **va** pür **pre** shur): The amount of pressure put forth by the water that is in air at different temperatures.

crystallize (**kris** tuh liz): To form crystals. Water crystals are formed when water vapor cools and water molecules are pulled together.

manager (**ma** ni jür): A skilled person who directs or manages something.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

centimeter apart. Then, they placed the remaining thermometers at 5-centimeter intervals (Figure 2). (Can you tell how many thermometers were placed under the snow? Divide 20 centimeters by 5 centimeters.) The thermometers automatically recorded the temperatures at certain times during the day and night. They placed the pipe with the thermometers into the snow (Figure 3). The scientists were interested in studying avalanches on steep slopes. However, they made

Figure 2. The thermometers used by the scientists.

Figure 3. The placement of the thermometers in the snow.

Weak layer and new layer of snow.

their temperature measurements in a flat area at the bottom of a steep slope because it was safer and a more convenient place to record snow temperatures.

The scientists were interested in comparing the snow temperature at the different depths and times of the day and night. Then, when the weak layer had been buried by a new layer of snow, the scientists observed its *relationship* to avalanches in the area.

Reflection Section

- Do you think the snow's surface temperature changed more or less between day and night than the snow temperature under the surface? Why?

- What are two advantages of using a device to measure temperature automatically?

Results

Dr. Birkeland and his colleagues found that the snow's surface temperature changed a lot between daytime and nighttime. During the daytime, the snow surface was warmed by the sun and was much warmer than the snow under the surface. At night, the snow surface cooled and became much colder than the snow under the surface. The snow under the surface stayed close to the same temperature the whole time (Figure 4). With such wide variations in temperature between the surface snow and the underlying snow, the *water vapor pressure* in the snow also varied widely. During the cold night, water vapor traveled toward the surface. While near the surface, it became very cold and froze on nearby existing crystals. During the warm day the process reversed. Some of the crystals became water vapor again, and the vapor traveled down into the snow. When water vapor recrystallizes near the surface, it becomes crystals with sharp angles and flat sides (Figure 5). When new snow falls onto the old layer, it does not stick well to the flat crystals. This creates dangerous avalanche conditions.

Following the formation of the layer of crystals, new snow fell in the area of the study. For up to 9 days, there were avalanches in the region. The avalanches were formed because the new snow could not stick to the weak layer.

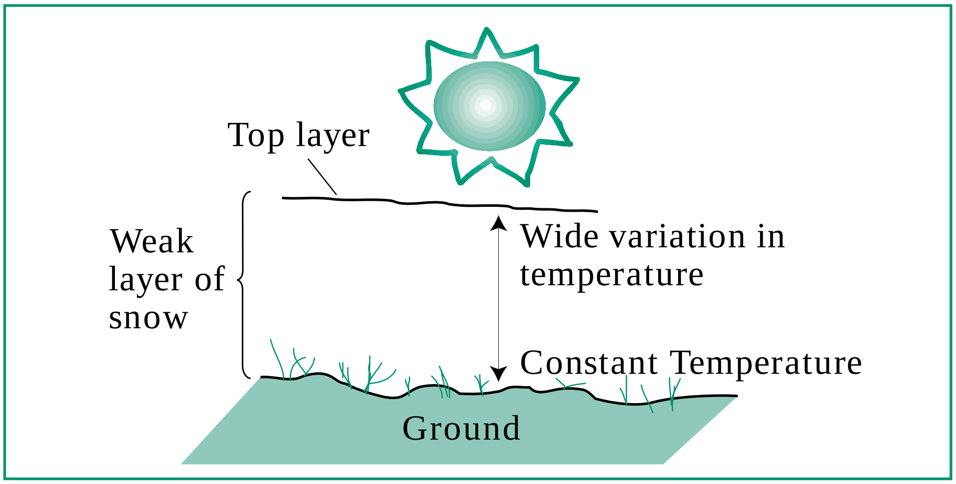


Figure 4. Comparison of temperature gradient between the top and lower layers of snow.

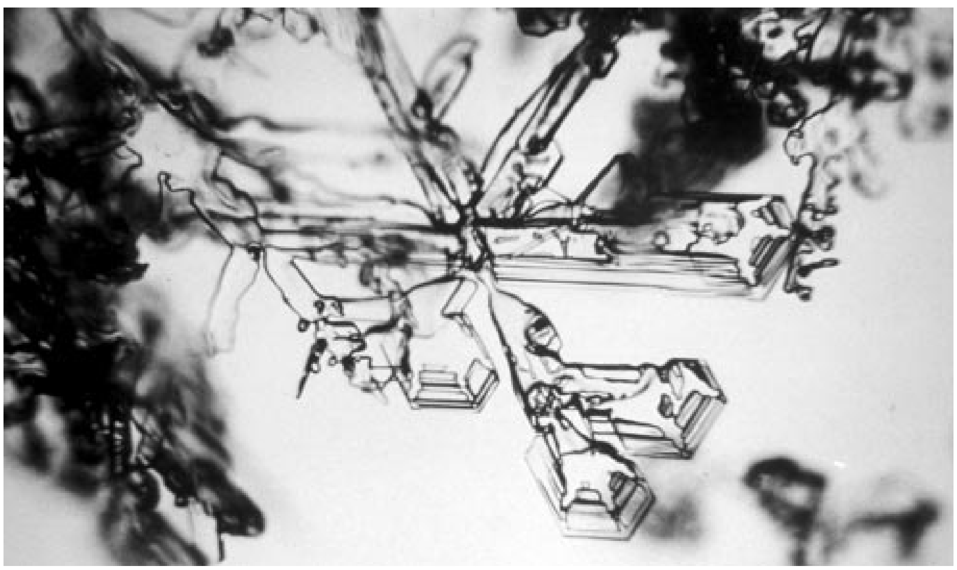


Figure 5. A crystal from a weak layer of snow.

The new snow built up so much weight that it broke apart on the weak layer. Once it broke apart, huge pieces slid down the slope in an avalanche.

Reflection Section

- Why do you think the snow under the surface stayed about the same temperature, regardless of whether it was day or night?
- Once an avalanche begins, what force makes it continue? Can you think of two other things that allow an avalanche to continue to slide?

Implications

The scientists discovered that a weak, crystallized layer of snow is formed during periods of clear, sunny days and clear, cold nights. Under these conditions, the snow surface temperature varies widely compared to the temperature under the snow. This causes variations in the water vapor pressure. The wide variation in water vapor pressure causes the water vapor to recrystalize at night near the surface. When it does this, a weak layer is formed that new snow may not be able to stick to. Skiers and other visitors to snowy mountain areas should be particularly careful during periods of clear weather followed by new snowfall.

Reflection Section

- Imagine you are the *manager* of a snow-covered mountain area. A group of skiers come to you and want to go skiing during a period of clear weather and new snowfall. You know the conditions are right for an avalanche. What would you tell the skiers? Why?
- What can a manager do to increase the safety of ski areas?

FACTivity

Get a cardboard box about 2 foot square. Fill it with Styrofoam peanuts. Take it outside into the sunlight. Get three thermometers. Place one thermometer into the center of the box, right in the middle of the Styrofoam peanuts. Lay the second thermometer under one layer of the peanuts. Place

Snow web-surfing

Avalanches can be dangerous for people out in snowy mountainous areas. Utah has a combination of large mountains, lots of snow, and cities totaling a million and a half people right at the base of a large mountain range. More people die from avalanches than from any other natural hazard in Utah. To increase people's safety, 2002 Games planners teamed up with the Forest Service's Utah Avalanche Center. They wanted to find ways to tell people about dangerous avalanche conditions. One way to do this is through the Internet. The Avalanche Center made its website easier to use. By visiting the website, people can find out which areas and weather conditions are dangerous for avalanches. They can even learn more about what makes avalanches happen. If you are interested in learning more about avalanches, visit www.avalanche.org or www.csac.org

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the third thermometer just outside of the box. Record the temperatures on all three thermometers every hour throughout the day. You may use the chart below or make one of your own. You will have to take the thermometers out of the box, then replace them in the same places after recording the temperature. Create a bar chart from your table. Study the table and the bar chart. What do they tell you about the insulating characteristics of Styrofoam? How is Styrofoam like snow? How is it not like snow?

Based on this FACTivity, consider the following questions:

1. Why is it useful to measure the air temperature as well as the temperature in the box?
2. How is this FACTivity similar to what the scientists did?

Sample Chart:

Date	Temperature in the box	Temperature on top layer of box	Air temperature
9:00 a.m.			
10:00 a.m.			
11:00 a.m.			
12:00 noon			
1:00 p.m.			
2:00 p.m.			

3. Of the temperatures inside the box, which has the greatest change in temperature? Why?

From Birkeland, Karl W.; Johnson, Ron F.; and Schmidt, D. Scott (1998). Near-surface faceted crystals formed by diurnal recrystallization: A case study of weak layer formation in the mountain snowpack and its contribution to snow avalanches. *Arctic and Alpine Research*, 30(2): 200-204.

Website:

http://www.avalanche.org/~uafc/

Kid's snow page:
www.teelfamily.com/activities/snow

Snow crystals page:
www.its.caltech.edu/~atomic/snowcrystals/primer/primer.htm

Students—**Tell Us What You Think About *The Natural Inquirer***

PLEASE COPY THIS FORM BEFORE COMPLETING

1. The article I read was entitled:

- ☐ Beetles Are Supercool!
- ☐ Let Nature Take Its Course
- ☐ What Is the Impact of the Impact Monster?
- ☐ Should Ditches Be Graded?
- ☐ Goldifinch and the Three Scales
- ☐ Big Fish in a Small Pool
- ☐ Turn That Radio Down!
- ☐ Excuse Me While I Flow My Snows

Circle the answer that best describes how you feel about the article you just read.

2. The article was:

   Easy to understand

   Hard to understand

   Very hard to understand

3. The article was:

   Very interesting to read

   Somewhat interesting to read

   Not interesting to read

4. Did you learn something from reading the article? ☐ Yes ☐ No

5. Did you try to answer the Reflection Questions?
   ☐ Yes ☐ No ☐ Some of them

   If you read and tried to answer any of the reflection questions, did they help you to think about the article? ☐ Yes ☐ No

6. Would you like to read another article?

   ☐ Yes ☐ No

7. How old are you? *(Circle)*

   9 10 11 12 13 other age: _____

8. What grade are you in? *(Circle)*

   4th 5th 6th 7th 8th 9th

9. Are you a girl or a boy?

   ☐ Girl ☐ Boy

Now write in your answer:

10. What did you learn from reading the article?

____

____

____

____

____

____

____

11. What is your favorite subject in school?

____

____

Along with your class or by yourself, please send this form to:

Dr. Barbara McDonald
USDA Forest Service
320 Green St.
Athens, GA 30602-2044

Thank you!

The Natural Inquirer—Teacher Evaluation

PLEASE COPY THIS FORM BEFORE COMPLETING

For each article that you read, please answer the following:

Name of Article:__________________________

1. Would this article help you meet any of the required statewide science curriculum standards? ☐ Yes ☐ No

2. How close to the appropriate reading and comprehension level for your students is this article written?

☐ Very close

☐ Somewhat close

☐ Not close

3. If the article is somewhat close or not close to the appropriate reading and comprehension level, is it:

☐ Too hard

☐ Too easy

4. Would or did you use this article in your classroom as an educational resource?

☐ Yes ☐ No ☐ Why or why not?

____

____

____

____

5. Please rate the article sections on a scale of 1 to 5. One means the section was not useful at all, five means the section was very useful.

	Not useful				Very useful
FACTivity	1	2	3	4	5
Glossary	1	2	3	4	5
Introduction	1	2	3	4	5
Methods	1	2	3	4	5
Results	1	2	3	4	5
Graphs, figures, photos	1	2	3	4	5
Reflection Section	1	2	3	4	5
2002 Games Sidebar	1	2	3	4	5

6. For any of the sections you rated with either a "one" or a "two" in question 5, please indicate why the section was not useful or how it can be improved:

FACTivity

____

____

Glossary

____

____

Introduction

____

____

Methods

____

____

PLEASE CONTINUE THIS EVALUATION ON THE NEXT PAGE ☞

Results

Graphs, figures, photos

Reflection Section

2002 Games Sidebar

7. Was the "Note to the Teacher" useful to you?

☐ Yes ☐ No ☐ Somewhat

8. What grade(s) do you teach? ______

9. What subject(s) do you teach?

10. Other comments or suggestions:

Please send this evaluation, along with your students' evaluations, to:

Dr. Barbara McDonald
USDA Forest Service
320 Green St.
Athens, GA 30602-2044

Thank you! Your evaluations will help us to continually improve *The Natural Inquirer.*

Which National Science Education Standards Can Be Met by The Natural Inquirer?

Standards	BEETLES ARE SUPERCOOL!	GOLDIFINCH AND THE THREE SCALES	TURN THAT RADIO DOWN!	WHAT IS THE IMPACT OF THE IMPACT MONSTER?	EXCUSE ME WHILE I FLOW MY SNOWS	LET NATURE TAKE ITS COURSE	SHOULD DITCHES BE GRADED?	BIG FISH IN A SMALL POOL
Science as inquiry								
Abilities necessary to do scientific inquiry	X	X	X	X	X	X	X	X
Understandings about scientific inquiry	X	X	X	X	X	X	X	X
Life Science								
Structure & function in living systems								
Reproduction & heredity	X		X					
Regulation & behavior	X	X						X
Populations & ecosystems	X	X	X			X		X
Diversity & adaptations of organisms	X	X				X		
Earth & Space Science								
Structure of the earth system	X				X	X	X	
Science & Technology								
Understandings about science & technology	X		X		X		X	X
Science in personal & social perspective								
Populations, resources & environments		X	X	X		X	X	X
Natural hazards	X		X		X	X	X	
Risks & benefits					X		X	
Science & technology in society	X	X	X	X	X	X	X	X
History & nature of science								
Science as a human endeavor	X	X	X	X	X	X	X	X
Nature of science	X	X	X	X	X	X	X	X
Physical Science								
Motions & forces					X			

What is the Forest Service?

The Forest Service is part of the Federal Government. It is made up of thousands of people who care for the Nation's forest land. The Forest Service manages over 150 national forests and almost 20 national grasslands. These are large areas of trees, streams, and grasslands. National forests are similar in some ways to national parks. Both national forests and national parks provide clean water, homes for animals that live in the wild, and places for people to do fun things in the outdoors. National forests also provide resources for people to use, such as trees for lumber, minerals, and plants used for medicines. Some people in the Forest Service are scientists, whose work is presented in this journal. Forest Service scientists work to solve problems and provide new information about natural resources so that we can make sure our natural environment is healthy, now and into the future.

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Conservation Education:
www.fs.fed.us/outdoors/nrce/

Rocky Mountain Research Station:
www.fs.fed.us/rm/

NatureWatch:
www.fs.fed.us/outdoors/naturewatch/default.htm

Woodsy Owl:
www.fs.fed.us/spf/woodsy

Smokey Bear:
www.smokeybear.com

National Forest Information:
www.fs.fed.us/recreation/map.shtml

National Forest Recreation:
www.fs.fed.us/recreation/recreation.shtml

USDA Kid's Page:
www.usda.gov/news/usdakids/index.html

Olympic Winter Games of 2002
www.saltlake2002.com

2002 Olympic Winter Games Education
www.uen.org/2002